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PRIORITIZING ISSUES IN THE BATTLEFIELD DEVELOPMENT PLAN

by

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Presented to Columbia Pacific University in partial fullfillment of the requirements for the degree of: Doctor of Philosophy

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The Battlefield Development Plan (BDP) has been a key product of the Concept Based Requirements System (CBRS) since it was first published in 1978. A list of prioritized issues contained in its Appendix A has constituted a planning guide widely used by Army agencies for budgetary purposes. This dissertation discusses the prioritization process employed to develop the prioritized issue list for the Battlefield Development Plan for 1989 (BDP-89) with emphasis on the analytical technique - the multiple attribute decision tree technique. The history of the Battlefield Development Plan from its beginnings in 1978, its relationship to the other products of the CBRS, and events leading to the decision to adopt a new prioritization technique are presented. The development of BDP-89 began with the Close Combat Capability Analysis (CCCA), designated as the umbrella study for the Mission Area Analysis (MAA) process cycle begun in 1987. The purpose of the CCCA was twofold - to provide the corps perspective of the battlefield and establish the consistency missing in earlier MAAs by setting force structure, equipment, and overall threat; and secondly to provide a

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prioritized list of capability issues as the basis for BDP-89. The multiple attribute decision tree technique was developed to produce the initial list of ordered issues used as a start point by the General Officer Steering Committee of the Close Combat Capability Analysis whose final prioritization of the capability issues served as the basis for BDP-89. At the conclusion of the BDP-89 development process, the list of 117 prioritized capability issues was distributed to all Army agencies involved in planning and programming budget activities, and included as Appendix A in BDP-89.

FORWARD

I wish to express my sincere appreciation to Major General Otstott, the Combined Arms Combat Developments Activity Commander; Colonel Kubasko, the Combined Arms Integration Directorate Director; and Lieutenant Colonel Riddle, the Operations and Combat Developments Branch Chief for giving me the task to develop an analytical technique and to use it to produce the initial prioritized list of capability issues identified in the Close Combat Capability Analysis. Their collective confidence in my ability to do the task assigned provided me the opportunity to write this dissertation and complete the requirements for my Doctor of Philosophy degree.

Mary C. Fischer

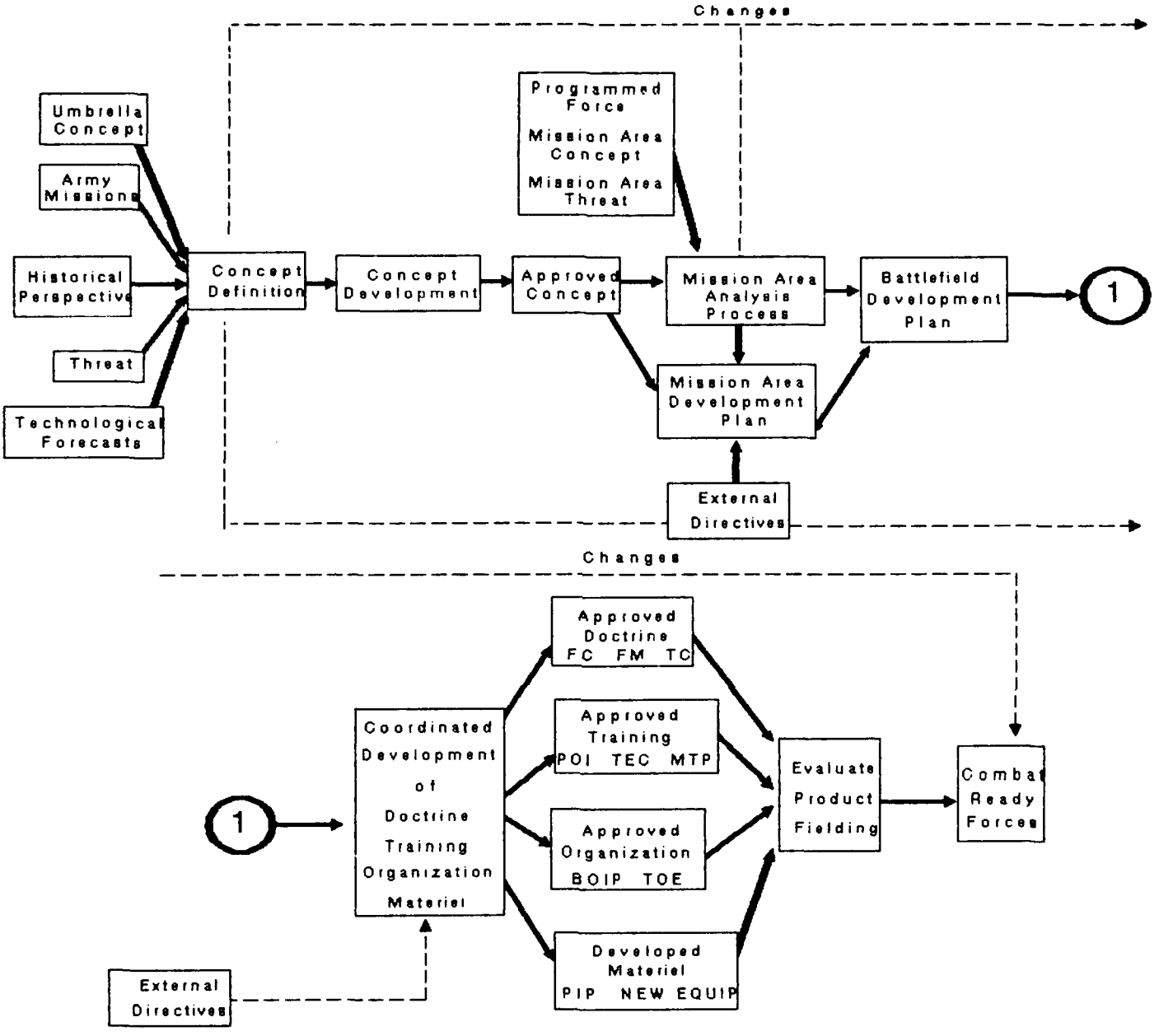
Prioritizing Issues in the Battlefield Development Plan

I. Introduction

The Battlefield Development Plan (BDP) is a key product of the Concept Based Requirements System (CBRS). CBRS is the manner in which the United States Army Training and Doctrine Command (TRADOC) determines the requirements of the Army to fight and win on the future battlefield. Within the system are a number of processes and products which require prioritizing issues or items, in order to influence the Army's portion of the budget request sent to the President from the Department of Defense. The most widely known and used of these products is the BDP. Before the importance of the BDP can be appreciated, an introduction to CBRS, its products and processes, is necessary.

II. Concept Based Requirements System.

In the mid 1970s, as the United States Army's involvement in the war in Viet Nam ended, Congress began to ask hard questions about the need for large expenditures for men and equipment. Often the Army did not have an adequate rationale for their budget requests. As a result, the Army began to lose ground in its annual allocation of funds. Army leaders saw that the best solution would be to tie budget requests to mission requirements, and to have an analytical basis to substantiate requests.



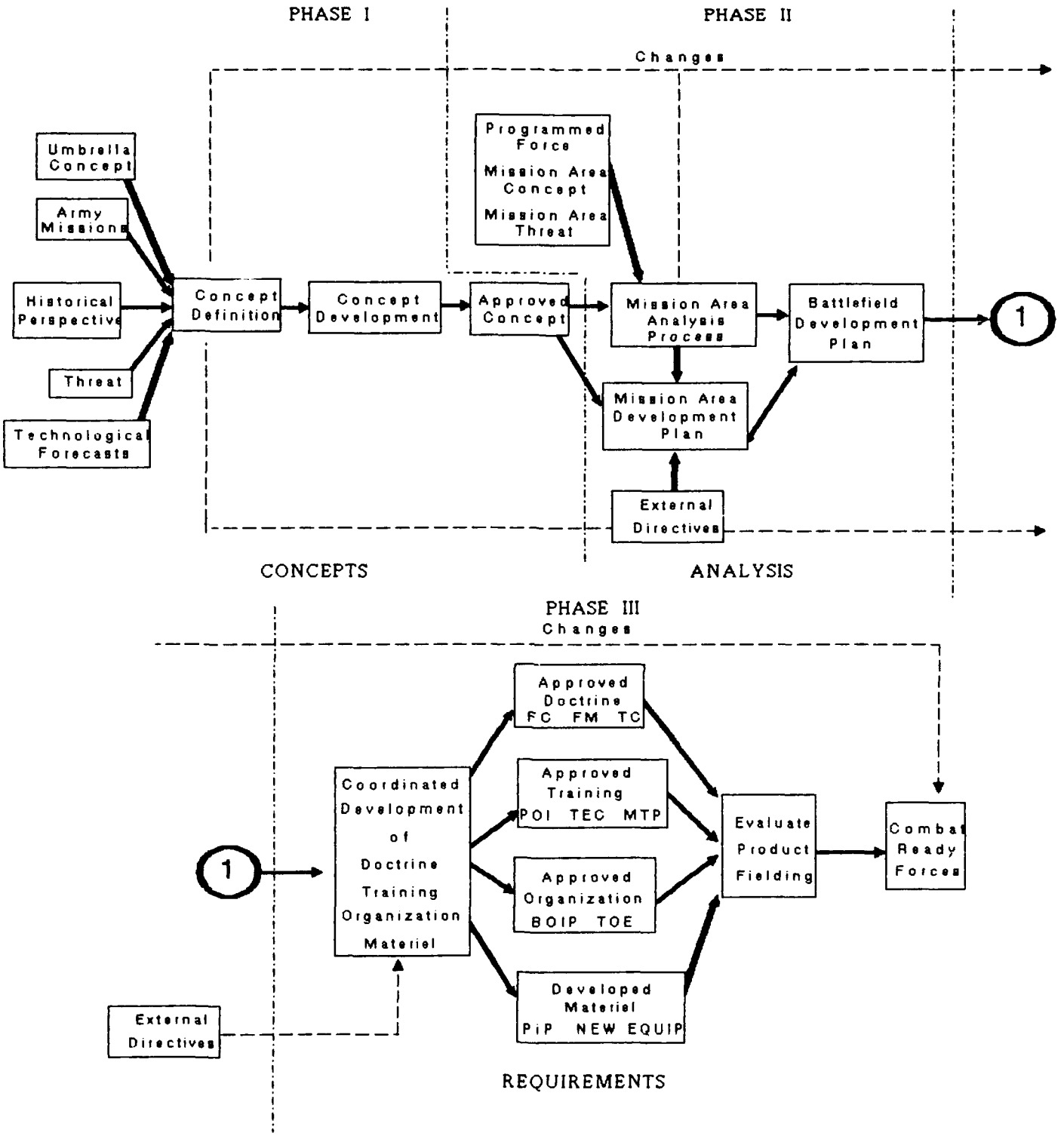
Concept Based Requirements System [1]
Figure 1.

[1] U. S. Army Training and Doctrine Command Reg 11-15 Concept Based Requirements System (Fort Monroe, VA: TRADOC, 4 Aug 1986), p.2-2.

The U.S. Army Training and Doctrine Command (TRADOC) was assigned the mission to establish the Army's requirements in doctrine, training, force structure, and materiel. The need to establish analytically the requirements in an orderly manner initiated the development of a process which has become known as the Concept Based Requirements System (CBRS). A pictorial representation of the system is shown in figure 1.

The discussion of CBRS divides quite naturally into three parts - concepts, analysis, and requirements. This is shown in figure 2.

A. Concepts. The concepts phase of CBRS begins with consideration of five important inputs, and ends with the development of an approved operational concept. Consideration of the umbrella concept (currently, AirLand Battle) of how the Army will fight and win on the future battlefield, the Army missions as defined with respect to the umbrella concept, the historical perspective of the current concept, the threat ability to counter the Army's operations, and technological advances that may impact the execution of the current concept, may identify the need to adjust or completely redefine a current operational concept. All of the five areas of consideration provide input to the concept definition which defines the way an operation is to be accomplished. The concept definition will become an approved concept after review and acceptance by the mission areas affected by proposed changes, and world-wide staffing to Army major



Three phases of CBRS
Figure 2.

commands. Approved operational concepts are used during the analysis phase of CBRS, as well as by units in the field. In addition to the work within CBRS, many external influences can impact the development of concepts, and at various stages the need for change can start the cyclical process anew.

B. Analysis. The analysis phase of CBRS is the true heart of the system. Central to this phase is the Mission Area Analysis (MAA) Process, shown in figure 3. In order to facilitate analysis of the Army's capabilities on the battlefield, the battlefield mission was divided into the twelve mission areas listed with proponency assigned to the center or school indicated.

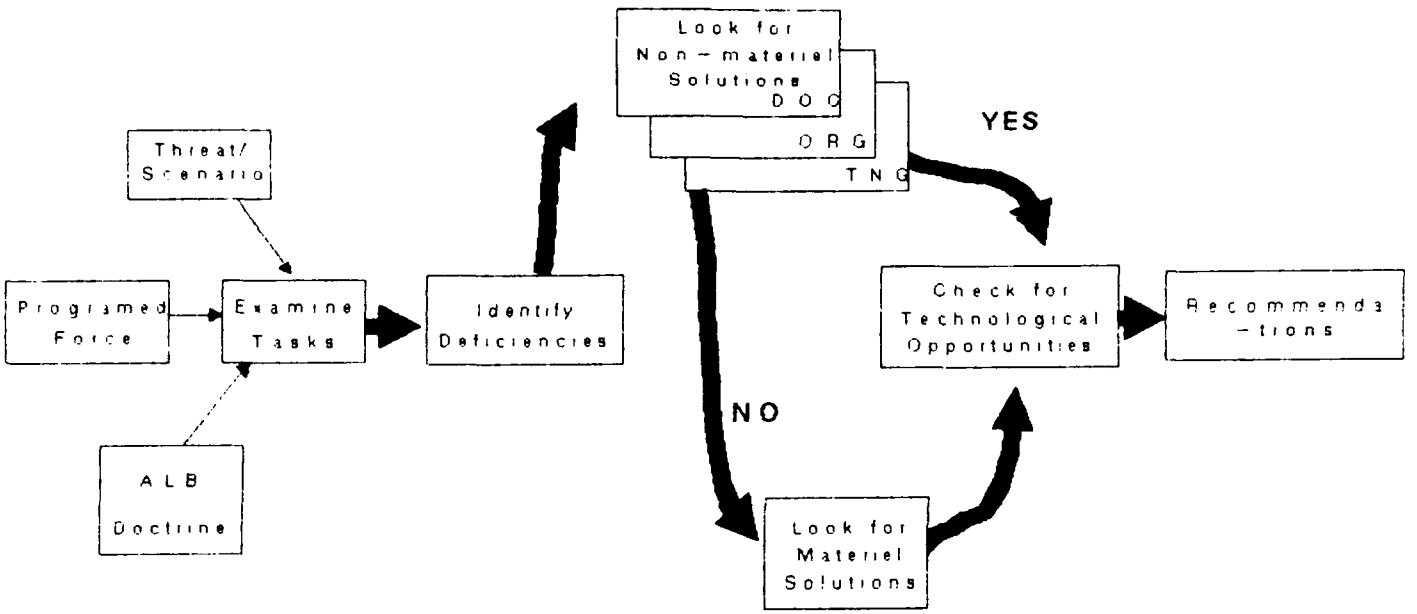
MISSION AREA	PROPONENT SCHOOL/CENTER
Air Defense (ADA)	US Army Air Defense Artillery School
Aviation (AVN)	US Army Aviation Center
Close Combat Heavy (CCH)	US Army Armor School
Close Combat Light (CCL)	US Army Infantry School
Combat Service Support (CSS)	US Army Logistic Center
Command & Control (CC)	US Army Combined Arms Combat Developments Activity (CACDA-C3I)
Communications (COM)	US Army Signal School
Engineer, Mine Warfare (EMW)	US Army Engineer School
Fire Support (FS)	US Army Field Artillery School
Intelligence, Electronic Warfare (IEW)	US Army Intelligence School

MISSION AREA	PROPONENT SCHOOL/CENTER
Nuclear, Biological, and Chemical (NBC)	US Army Chemical School
Special Operations (SO)	US Army JFK Special Warfare Center

Each mission area proponent is responsible for conducting a Mission Area Analysis (MAA) on a schedule set by the Headquarters of the US Army Training and Doctrine Command (TRADOC). Three centers were established to ensure the integration of the results of the MAA process. These integrating centers are by order of seniority: the US Army Combined Arms Center (CAC) responsible for the mission areas ADA, AVN, CCH, CCL, CC, COM, EMW, FS, IEW, NBC, and SO; the US Army Logistics Center (LOGC) responsible for the mission area CSS; and the US Army Soldier Support Center (SSC) supporting the LOGC mission area.

A Mission Area Analysis is an assessment of the programmed force capability to fight as specified within a particular mission area concept. It is designed to discover efficiencies and deficiencies in warfighting capabilities, and to identify means of correcting or exploiting these. The MAA process begins with the three basic inputs shown in figure 3, the Programmed Force, the Mission Area Concept (MAC), and the Mission Area Threat (MAT). The Programmed Force is defined as the Program Objective Memorandum (POM) force (the current cycle of MAAs will use a 1992 programmed force) and is used to give consistency to the separate MAAs. MACs are developed through coordination with all

functional proponents participating in accomplishing the mission area's portion of the battlefield mission. MATs are developed by considering the threat capabilities to counter the components of the mission area.



MAA Process [2]
Figure 3

The MAA identifies capability issues (deficiencies and efficiencies) that impact on the accomplishment of the battlefield mission. It may also identify possible corrective

[2] U.S. Army Training and Doctrine Command The Battlefield Development Plan for 1985 (Fort Monroe, VA: TRADOC, 26 Dec 1985), p.4-3.

actions and/or enhancements (changes in doctrine, training, organization, and materiel development) that could improve or enhance the accomplishment of the mission. The capability issues are carefully studied, and those requiring Department of the Army recognition are forwarded for inclusion in the Battlefield Development Plan (BDP).

All capability issues resulting from the MAA are included in the Mission Area Development Plan (MADP) along with detailed descriptions of the measures being undertaken to correct or enhance the capabilities at issue. The BDP is a single document to which all mission areas contribute while there are 12 MADPs, one for each mission area. The BDP prioritizes the issues relative to what is important to the total Army mission, and influences the prioritizing of the issues in each individual MADP. An MADP is its proponent's roadmap to the solution of issues. A mission area proponent must first work to solve the capability issues as the Army prioritizes them, then it can work on the issues in its own individual area of concern.

The BDP and the 12 proponent MADPs taken together provide the information necessary to understand what must be done in the requirements phase of CBRS.

C. Requirements. Once the issues have been prioritized and detailed information about solutions being investigated has

been collected, an effort to coordinate the development of corrective actions in doctrine, training, organization, and materiel begins. The purpose is to eliminate duplication of effort, and ensure that the best solution strategy is being undertaken. Currently a formal coordination document does not exist that lays out the result of this effort. However, review of the documents that initiate changes to current doctrine, training, organization, and materiel by integrating centers assists in coordinating these corrective actions. Thorough review and coordination eventually results in approved changes in one or more corrective action areas. These changes in doctrine, training, organization, and materiel are sent to the field for implementation. Feedback from the ultimate user cycles back into the analysis process.

CBRS is a process that allows for field user input and external directives that, coupled with the five initial inputs, will ultimately result in combat ready forces.

III. Battlefield Development Plan.

The Battlefield Development Plan (BDP) "provides a perspective of the future battlefield in terms of expected environment, threat, doctrine, capability assessment, and guidance to correct problem areas. It consolidates and prioritizes the major deficiencies

identified in all proponent MAA and MADP updates. It is used by TRADOC to prioritize developmental work in the areas of doctrine, training, organization, and materiel." [3]

The first Battlefield Development Plan (BDP) was published in November 1978. It was called BDP I. This historic first document was developed in an effort to set out the Army's combat developments strategy. "BDP I attempted to describe the battlefield in a functional manner useful to the military analyst ... the tactical focus of the Army, which was to win the central battle ... to include those actions required to be prepared for a central battle, the concept of force generation. The result of this effort was the defining of central battle with the critical tasks (battlefield functions) of target servicing, counterfire, air defense, battle support (logistic support) and command, control and communications in the EW environment (C3/EW) and the defining of force generation with the critical tasks of surveillance/fusion, interdiction, reconstitution, force mobility and C3. These critical tasks were used in BDP I to introduce the force generation concept, with its focus on fighting the second echelon and reconstituting the force at the right time and place, then to assess the division's capability to perform these

[3] TRADOC Reg 11-15 Concept Based Requirements System, p. 2-9.

tasks." [4] This first BDP did not result from rigorous analytical capability studies, but rather set the framework for the development of the Army 86 concept development, the key contribution being the comprehensive airland battlefield analysis built upon the framework of the central battle and force generation.

BDP II was published in March 1981. In much the same vein as BDP I, this document presented an operational concept and an assessment of the Army's capabilities for a period ten years in the future. The concept was updated to include the integrated battlefield, the emerging airland battle doctrine, and the corps' capability on the battlefield. BDP II brought focus to TRADOC's "efforts in concept and doctrine development, force structure, training and manning the force, and materiel acquisition. In so doing, it provides a capstone mission area analysis which identifies the Army's requirements across mission areas in these four modernization categories. It also serves to provide TRADOC's views on major issues to the Department of the Army and other agencies outside TRADOC." [5]

[4] U.S. Army Training and Doctrine Command (ATCD-AN-M) Letter Enclosure 1 Memorandum For Record Subject: The Functional Description of the Battlefield, 28 April 1979, p. 1.

[5] U.S. Army Training and Doctrine Command, Battlefield Development Plan II (Fort Monroe, VA: TRADOC, 31 Mar 1981). Forward.

The first cycle of MAAs was conducted from 1980 to 1983. Thirteen MAAs [6] were completed by the end of 1983. The Battlefield Development Plan for 1982 (BDP-82) is best described by General Otis, the TRADOC Commander in 1982, in his Forward to the document, "BDP-82 is a transitional document which summarizes those MAA which were completed prior to June 82 and uses the emerging results from MAA completed after that date. Thus, BDP-82 rests on a better analytical base than does its predecessors and goes well beyond previous BDP in identifying, integrating, and prioritizing deficiencies." [7] BDP-82, like its predecessors, was considered to be a keystone document for Army analysis, however, with the completion of thirteen MAAs, subsequent BDPs became more of a capstone for the MAA process.

The Battlefield Development Plan for 1983 (BDP-83), published after the completion of thirteen MAAs, represented the first time that TRADOC "was able to identify, integrate, and logically prioritize deficiencies based on a complete set of mission area analyses." [8] It became a true capstone document for the MAA process summarizing the MAA results and integrating them into a

[6] The number of mission areas was reduced to the current twelve when the Battlefield Nuclear Warfare (BNW) mission area was converted to a functional area in October 1987.

[7] U.S. Army Training and Doctrine Command, Battlefield Development Plan 1982 (Fort Monroe, VA: TRADOC, 1982).

[8] TRADOC, Battlefield Development Plan for 1985, Forward.

single prioritized list of deficiencies against which specific corrective actions could be recommended. The prioritized list of deficiencies is found in Appendix A of BDP-83.

The Battlefield Development Plan for 1984 (BDP-84) was a refinement of BDP-83. It was published in December 1984 in order to align more closely with the planning, programming, budget, and execution system (PPBES), and to contribute to the Department of the Army efforts in the preparation of the POM.

Appendix A to the Battlefield Development Plan for 1985 (BDP-85) contained a substantially expanded list of prioritized battlefield deficiencies derived by a combination of subdividing deficiencies from the BDP-84 list and including additional deficiencies from the total of 1400 identified by the thirteen MAAs. This attempt to gain specificity in deficiency statements and solution direction, a departure from previous efforts to summarize and integrate MAA results was undertaken at the request of industry who, when briefed on BDP-84 found the deficiency statements too broad to determine what might be done to resolve them. A major re-prioritization of the deficiencies was undertaken that involved more than thirty general officers throughout TRADOC. The pairwise comparison [9] technique used

[9] An excerpt from the BDP-85 Letter of Instruction (LOI) explaining the pairwise comparison technique is provided in Appendix A.

resulted in a prioritized list of 451 deficiencies. The list of deficiencies for BDP-85 was used to determine priorities for programs in the Army's Long Range Research, Development, and Acquisition Plan (LRRDAP) by assigning values to each program in line with its contribution to the resolution of BDP deficiencies. BDP-85 was the last BDP to be published complete with narrative chapters and supporting appendices.

The Battlefield Development Plan for 1986 (BDP-86) was developed using BDP-85 as a basis, with the constraint that changes in priority would be limited in scope. This latter requirement was an effort to meet the materiel developers request for consistency from year to year. There was a change in thrust in BDP-86. The goal was to orient more on the task and mission that was deficient rather than the possible solution, and to eliminate redundancy across mission areas, as well as within mission areas. The number of deficiencies prioritized in BDP-86 was reduced to 356 from the 451 in BDP-85. Only Appendix A of BDP-86 was published in late 1987.

The goal to eliminate redundancy and focus on task and mission continued throughout the development cycle for the Battlefield Development Plan for 1987. The streamlined list of deficiencies contained in Appendix A of BDP-87 totaled 230. The prioritized list of deficiencies for BDP-87 was approved by the TRADOC Commander in May 1987, and distributed to all Army agencies for use in planning and preparation of budget requests. Publication

of BDP-87 has been delayed. A short summary of the history of the BDP with pertinent points is given in Table 1.

In 1987 when the Army went to a biennial budget process, TRADOC went to a biennial BDP development cycle. BDP-87 was the last of the annually developed BDP. During the development of BDP-87, the senior leadership at the Combined Arms Center (CAC) expressed dissatisfaction with the manner in which the deficiencies incorporated into the BDP were developed, and in the methodology used to prioritize those deficiencies. The result was an order to design an alternate methodology for the development of the BDP, and to implement it in the development of the Battlefield Development Plan for 1989.

HISTORY OF THE BDP

BDP I (1978)
- Framework for Army 86 Concept Development
- Limited analytical basis/examined critical tasks

BDP II (1981)
- Prelude to Airland Battle Doctrine
- Included integrated battlefield/corps capability

BDP-82
- Transition document for ongoing MAA
- More analytical look at tasks/missions

BDP-83 (March 1984)
- First integration of 13 MAAs
- Highlighted 235 most critical deficiencies

BDP-84 (December 1984)
- Refined to list of 229 deficiencies
- Published to coincide with PPBES cycle

BDP-85 (January 1986)
- Expanded to 451 deficiencies for specificity
- Prioritized with pairwise comparison by 30 GOs

BDP-86 (Appendix A in 1987)
- Revised to eliminate redundancy/address tasks
- Deficiencies reduced to 356

BDP-87 (Publication delayed)
- Further refinement to 230 deficiencies

Table 1.

IV. Battlefield Development Plan for 1989.

Many events ultimately impacting on the development of the Battlefield Development Plan for 1989 (BDP-89) occurred prior to distribution of the Memorandum of Instruction initializing the development cycle in June 1988. Concern with the lack of senior level involvement in the BDP process, the parochial views fostered by the mission area proponents, the loss of the corps perspective on battlefield capabilities, the inconsistency of earlier analysis efforts, and the failure to consider efficiencies as well as deficiencies required major adjustments to insure these concerns were resolved. An alternative strategy for the development of the BDP had to be implemented, and the manner in which this would be accomplished required a different approach to the conduct of MAAs.

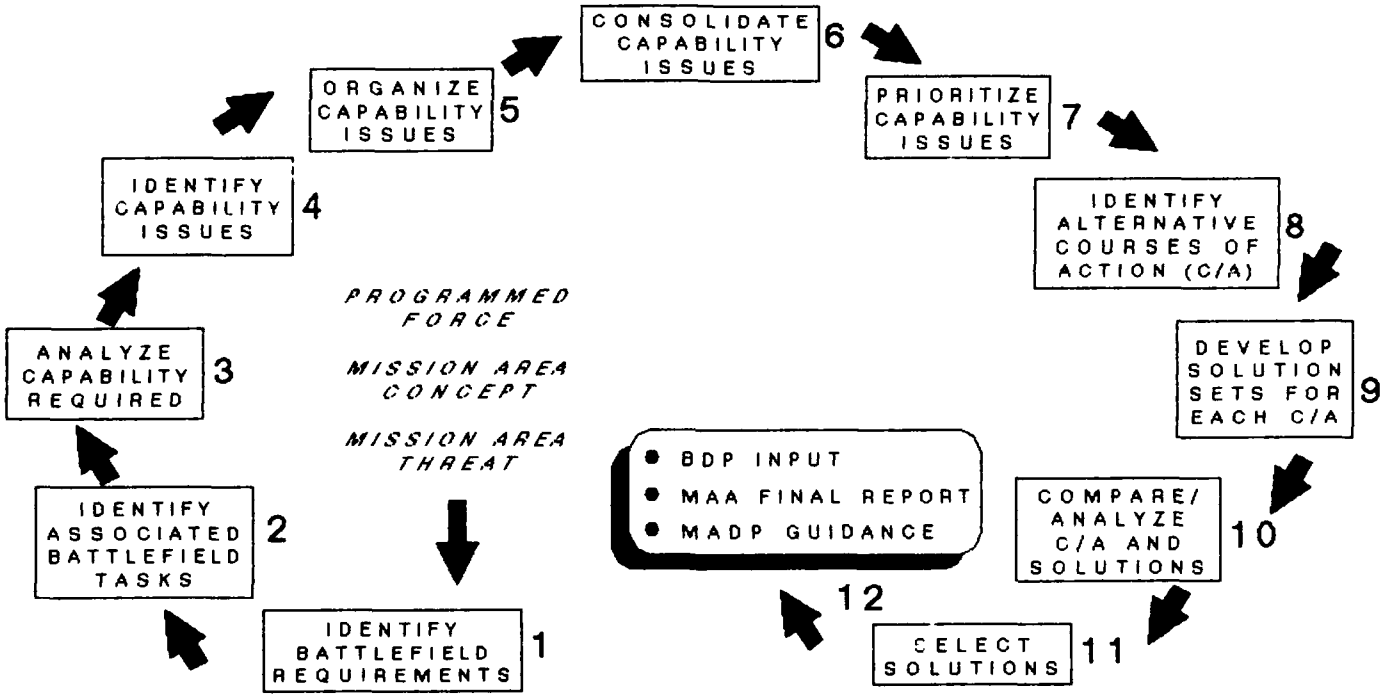
The original schedule for the second cycle of MAAs called for four MAA to be conducted each year for three years. The start of this cycle was delayed until Fiscal Year (FY) 1987 while attempts were made to establish norms for the process. A Combined Arms Mission Area Analysis (CAMAA) was begun in 1985 in an attempt to pull together the aspects of the integrated battlefield from a corps perspective, but was abandoned due to analytical support problems. The initial idea of having an umbrella study to set the parameters for the MAAs had merit, and the decision was made by the TRADOC Commander to reduce to two the number of MAA to be conducted the first year of the cycle, and to add an umbrella

study to insure the corps perspective of a combined arms battlefield was used to establish the consistency that was missing in previous MAA. The umbrella study is the Close Combat Capability Analysis (CCCA), and conducted subordinate to it are the Close Combat Heavy (CCH) and the Close Combat Light (CCL) MAAs. All mission area proponents contribute subject matter expertise to support these three studies, thereby helping to lessen the parochial focus experienced in previous efforts. The three study groups (CCCA, CCH, CCL) initiated their analyses in October 1987. Completion of the final study reports is scheduled for January 1989. An information briefing to the TRADOC Commander on 16 March 1988 provided the organization, focus, and status for the CCCA and subordinate efforts. Slides used for that briefing pertinent to this discussion are provided in Appendix B.

The CCCA provides the corps perspective of the battlefield and establishes the guidelines to be followed in the subordinate analyses. It will insure consistency in the three analyses by setting the force structure, equipment, and overall threat to be considered. Senior leadership involvement is increased through the establishment of a General Officer Steering Committee to oversee and guide the analyses, Commandants' (TRADOC schools and centers) Reviews of the progress of the analyses, biweekly updates to the Combined Arms Center (CAC) and the Combined Arms Combat Developments Activity (CACDA) Commanders (the executive

agents f.. the CCCA), and quarterly information briefings to the TRADOC Commander.

The CCCA study team departed from the earlier methodology proposed for the conduct of MAAs, and established the new methodology shown in Figure 4. This methodology incorporates the



Close Combat Capability Analysis Methodology
Figure 4. [10]

Blueprint of the Battlefield, an analytical tool developed by Dynamics Research Corporation under the auspices of the Army

[10] U.S. Army TRADOC Analysis Command-Fort Leavenworth, Close Combat Capability Analysis Study Plan (Fort Leavenworth, KS: TRAC, March 1988), p. C-10.

Research Institute for the TRADOC Deputy Chief of Staff for Doctrine (DCSDOC). This analytical tool assists in assuring that the analyses focus on the mission and tasks that must be performed to succeed on the battlefield, and thus will provide the desired mission and task orientation for the BDP. The capability issues (deficiencies and efficiencies) identified and

BDP-89 Milestone Schedule

AGENCY	ACTION	DUE
Phase I		
CACDA	Distribute CCCA Issues	19 Sep 88
MA Prop	Submit additional issues	14 Oct 88
ICs	Host O-6 Review Panel	8 Nov 88
ICs	*Distribute Strawman* List	21 Nov 88
Phase II		
MA Prop	Submit priority changes	5 Dec 88
ICs	Forward recommendations	6 Jan 89
Phase III		
TRADOC	Host 3-Star GO Panel	13 Jan 89
TRADOC	Forward BDP-89 to CG for approval	1 Feb 89

Table 2. [11]

[11] U.S. Army Training and Doctrine Command, Battlefield Development Plan for 1989 Memorandum of Instruction (Fort Monroe, VA: TRADOC, 28 June 88), Enclosure 2.

prioritized in the CCCA will form the basis for BDP-89. The direct connection of the CCCA and BDP-89 will answer the concerns expressed during the development of BDP-87. Table 2. provides a milestone schedule for the development of BDP-89 showing key events.

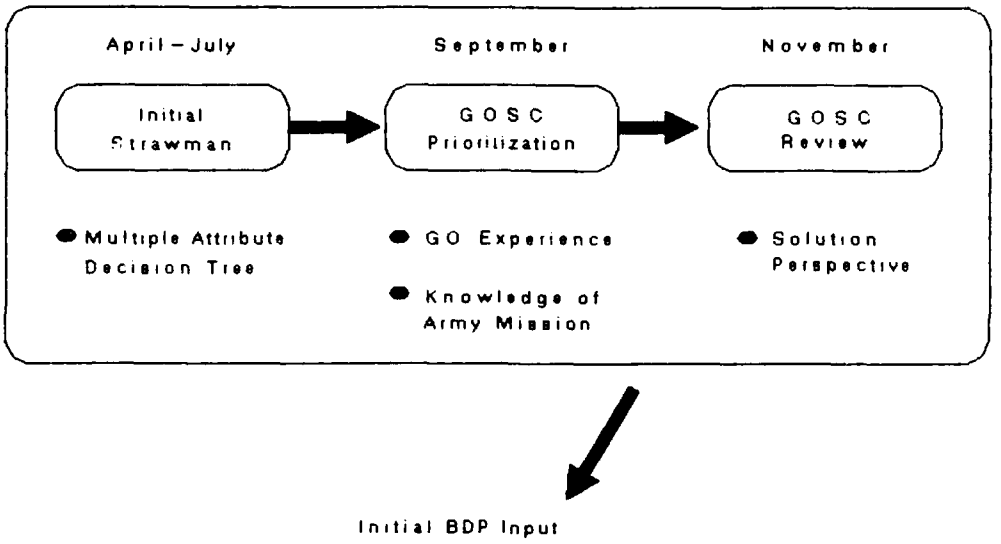
V. Prioritization Methodology

The prioritization methodology illustrated in Figure 5. is an expansion of block seven of the CCCA methodology shown earlier. It is a three phase process:

Phase I. April-July 1988. The results of the three study teams' efforts in accomplishing blocks one through six of the CCCA methodology will be used to develop a strawman list of ordered issues. A multiple attribute decision tree technique will be used to generate this initial list. A more detailed discussion of the analytical methodology will be undertaken in a later section.

Phase II. September 1988. The CCCA General Officer Steering Committee (GOSC) will convene to review the strawman list of ordered issues. Application of General Officer experience and knowledge of the Army mission and planning factors will produce a revised list of prioritized issues which will

focus the solution phase of the CCCA. This list will be forwarded to TRADOC and the mission area proponents to be used as the basis for BDP-89.



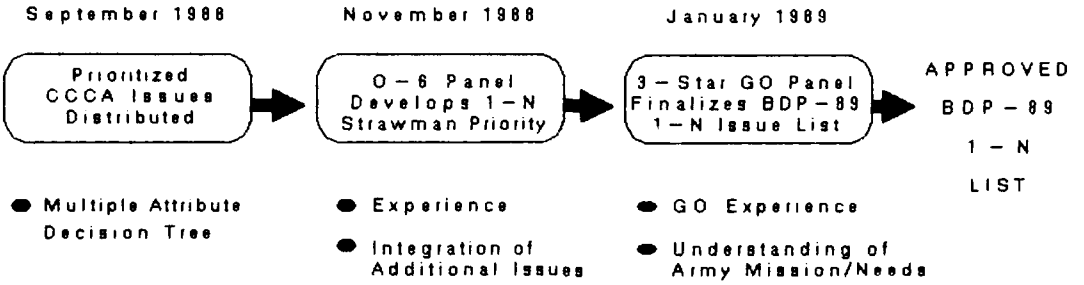
CCCA Prioritization Methodology
Figure 5.

Phase III. November 1988. The CCCA GOSC will revisit the prioritization of CCCA issues in light of the selected course of action and proposed solution sets. This solution perspective review will allow revisions that insure the best feasible prioritization of issues for BDP-89. The revised list of issues will be forwarded to TRADOC for incorporation into the BDP-89 Strawman 1-N List.

The methodology for prioritizing capability issues in BDP-89 is the CCCA prioritization methodology. Additional reviews of the

list of capability issues take place during BDP-89 development. This is illustrated in Figure 6.

The prioritized list of CCCA capability issues will be reviewed by TRADOC, CAC, LOGC, SSC, and all mission area proponents. Additional issues may be submitted for integration into the base CCCA list. A Council of Colonels will meet to determine the



BDP-89 Prioritization Methodology
Figure 6.

validity of the additional issues submitted and their placement relative to the prioritized capability issues in the base list. The BDP-89 Strawman 1-N List of prioritized capability issues resulting from this O-6 level review will be distributed to all mission area proponent for review at the general officer level. The mission area proponents may submit proposals for priority changes with supporting justification. The Three-Star General Officer Panel will review all valid requests and finalize the composition and prioritization of the list of capability issues for BDP-89. The finalized list will be forwarded to the TRADOC

Commander for approval. Once approved, the list of prioritized capability issues becomes Appendix A of BDP-89, and is distributed to all Army agencies involved in planning and programming budget activities.

VI. Multiple Attribute Decision Tree Technique.

The multiple attribute decision tree technique is based on the relationships and functions of Bayesian statistical decision theory. It was chosen and developed specifically for use with the Close Combat Capability Analysis (CCCA). Newman in Management Applications of Decision Theory states precisely the reasons for choosing this particular technique. "The main criteria for a decision tree are that it be suitable to the problem and helpful to the decision maker. There is no one best way to lay out a tree. It should be limited, however, to decisions and events that have consequences the decision maker wishes to compare. ... The decision tree can be of great value in helping management achieve an overall picture of the decision situation ... . The utility of the decision tree technique becomes more apparent as the decision problem becomes more complicated." [12] While this technique may be applied to other Army prioritization efforts, they are not the subject of this

[12] Joseph W. Newman, Management Applications of Decision Theory (New York: Harper & Row, 1971), p. 13.

treatise and the possibilities will not be investigated at this time.

The CCCA study methodology identified four attributes for consideration: theater/echelon/threat, battlefield requirements, tasks, and issues. These attributes were conditionally related, that is, after the first attribute was established all others were conditional upon the existence of the preceding attribute. For example, the CCCA established seven combinations of theater, echelon, and threat to be analyzed. For each combination a number of battlefield requirements were determined which represented the missions that must be accomplished to succeed on the battlefield. The exact nature of the battlefield requirements is dependent upon the particular theater, echelon, and threat combination under consideration, hence a conditional relationship. The battlefield requirement is selected because of the scenario being considered. In the same manner, Blueprint of the Battlefield tasks essential to the accomplishment of the associated battlefield requirement were selected. The analysis of each scenario determines whether an essential task is at issue, that is, is the capability to perform the task deficient or efficient? Each task determined to be a capability issue is identified as either a deficiency or an efficiency. A deficiency is "an inability or inadequacy in the performance of a task that is essential to the successful accomplishment of a battlefield

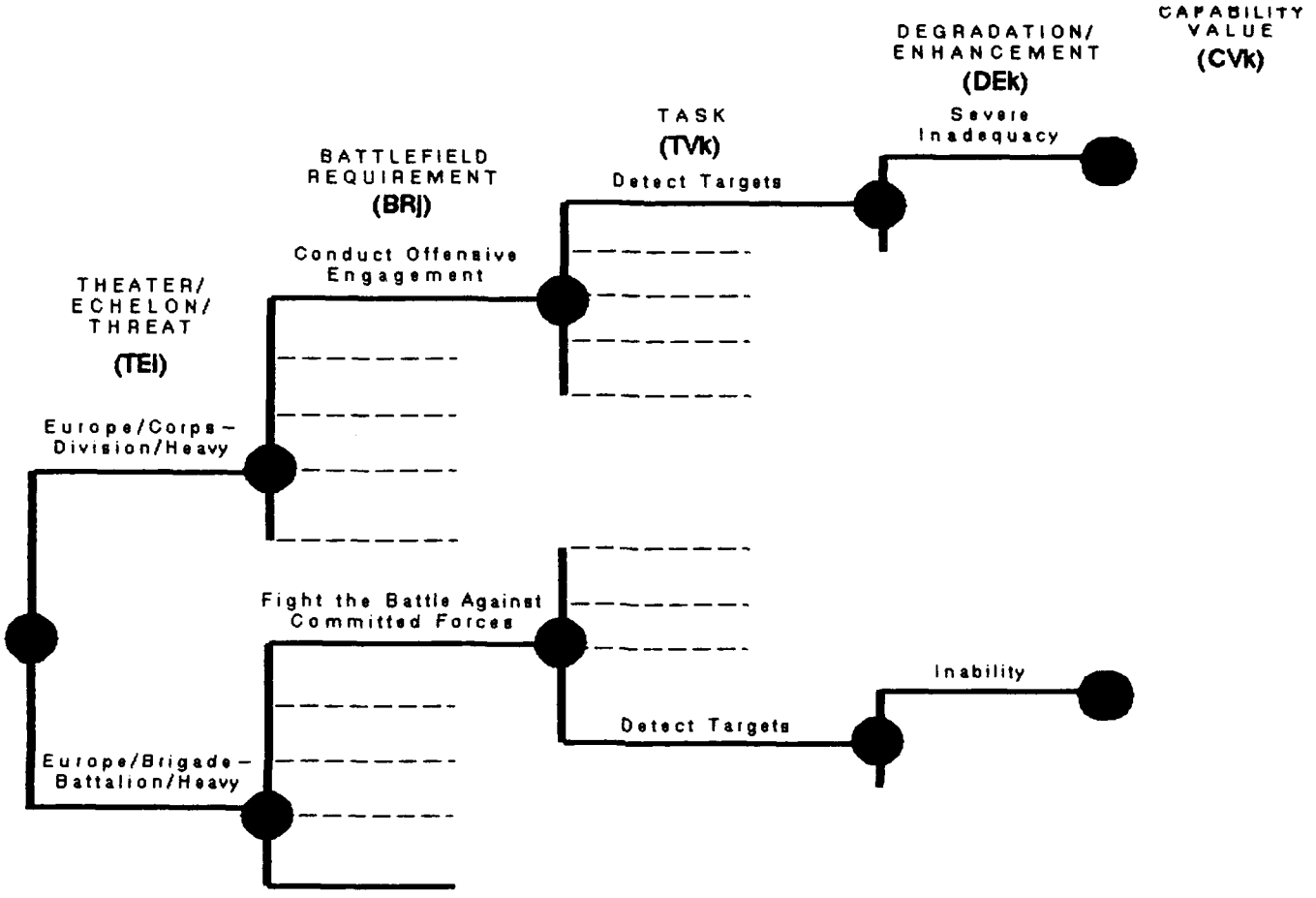
requirement." [13] A task is considered to be efficient when it is performed in a manner which provides the "opportunity to enhance ... potential in order to exploit a threat capability ... to gain a decided advantage." [14] Considering the CCCA methodology and the four attributes given, the multiple attribute decision tree technique was determined to be the most viable prioritization tool under the constraints of time and additional information the analyst was allowed to collect from the three study teams (CCCA, CCH, and CCL). A graphic representation of this multiple attribute decision tree is shown in Figure 7.

"Although the decision tree concept itself is simple, its implementation requires the skill and judgment that comes from experience. In a good many business decisions, structuring is the most difficult and most important part of the process." [15] The application of the multiple attribute decision tree technique to the prioritizing of capability issues identified in the CCCA was accomplished in seven basic steps.

[13] U.S. Army Combined Arms Combat Developments Activity (ATZL-CAI-I) Memo, Subject: Close Combat Capability Analysis (CCCA) Prioritization Methodology Inputs Memorandum of Instruction (MOI) Encl 4, Degradation/Enhancement Input, 22 April 1988, p.1.

[14] USCACDA, (ATZL-CAI-I) Memo, Subject: CCCA Prioritization Methodology Inputs MOI Encl 4, 22 April 1988, p.1.

[15] Newman, p. 15.



Multiple Attribute Decision Tree
Figure 7.

Step 1. Seven theater/echelon/threat (TEi) combinations were chosen for analysis. This first attribute is represented by the first set of branches on the decision tree. The seven combinations were ordered and valued on a scale of 0 to 100 at the General Officer level.

Step 2. Battlefield requirements (BRj) were established for each theater/echelon/threat combination. This second

attribute is represented by the second set of branches on the decision tree. The battlefield requirements were ordered according to their relative importance to the theater/echelon/threat combination with which they were associated, and assigned a value on a scale of 0 to 100 establishing their relationship one to another. That is, how much more important the first is than the second, the second than the third, and so forth. For example, if BR1 is assigned the value 95 and BR5 is assigned the value 70, then BR1 is 1.357 times as important as BR5. The valuation scale definitions utilized in this and subsequent steps is outlined below.

Prioritization Methodology Valuation Scale

VALUE	DEFINITION
100 - 81	Most Critical
80 - 61	Critical - Represents a turning point (success or failure) in accomplishment of objectives.
60 - 41	Significant - Represents a definite influence on the accomplishment of objective.
40 - 21	Important - Represents a valuable effort toward the accomplishment of objective.
20 - 0	Insignificant

Step 3. The essential Blueprint of the Battlefield tasks (TVk) associated with each battlefield requirement were determined. This third attribute is represented by the third set of branches on the decision tree. Each task was assigned a value

on a scale of 0 to 100 establishing its criticality to the accomplishment of the associated battlefield requirement. The list of essential Blueprint of the Battlefield tasks selected for analysis in the CCCA is presented in Appendix C.

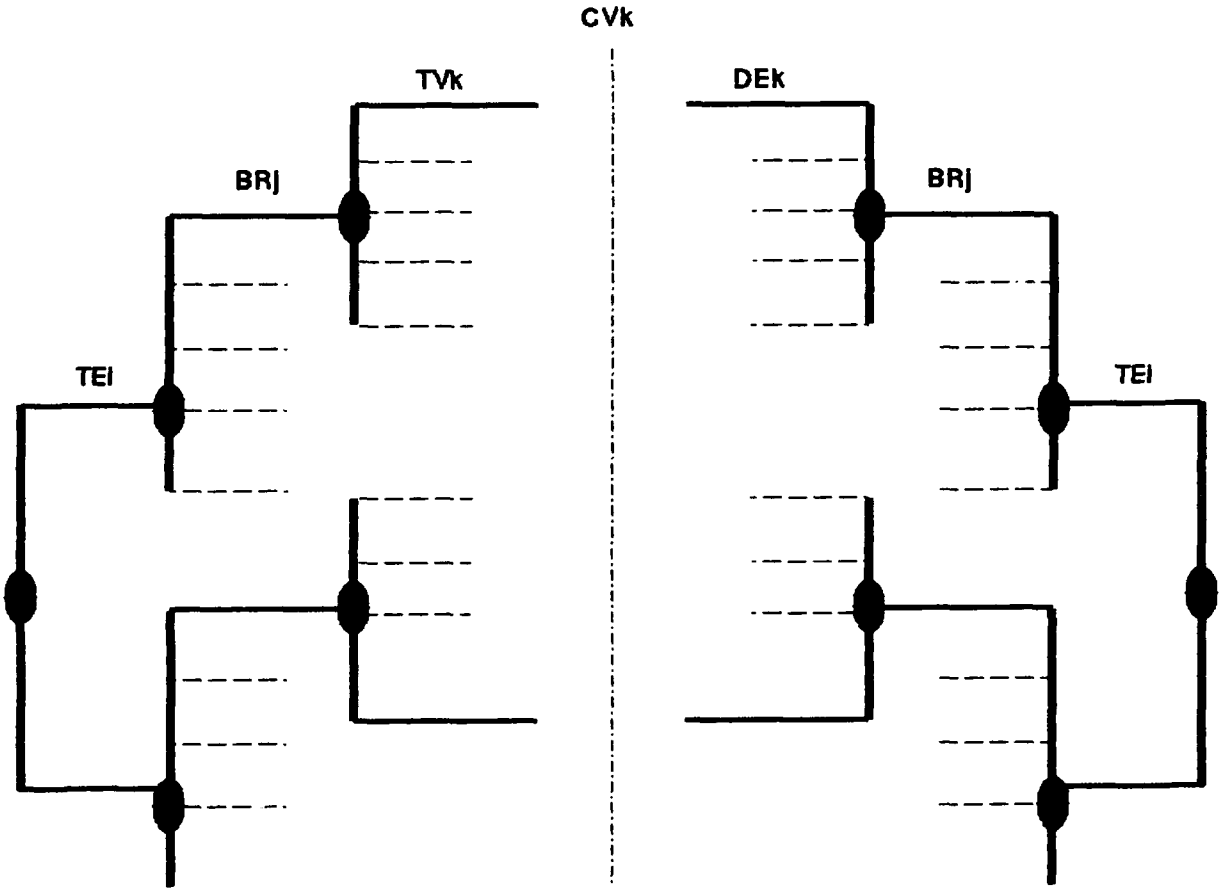
Step 4. The capability issues (DEk) identified during analysis are labeled as either deficiencies or efficiencies. This is the fourth attribute, and is represented by the fourth set of branches on the decision tree. Each capability issue is assigned a value on a scale of 0 to 100 representative of the amount of degradation or enhancement observed relative to the associated task and the conditions upon which it has impact.

Step 5. A capability value for each capability issue was calculated using a weighted factoring of the attribute values. The CAC senior leadership directed that task valuation be weighted less than degradation/enhancement valuation. A number of sensitivity runs yielded an optimal 40%-60% weighting. This also required a change from the original multiplicative relationship of the values to the relationship shown in the computational formula given below.

$$CVk = (TEi)(BRj)[.4(TVk) + .6(DEk)]$$

An illustration of the revised decision tree resulting from the decision to weight the TVk and DEk values is shown in Figure 8.

A discussion of the impact of these directed changes will be undertaken in a later section.



Revised Multiple Attribute Decision Tree
Figure 8.

Step 6. The capability issues from the three study teams were merged where appropriate to eliminate redundancies. These merged capability issues were placed in descending order based on their overall capability value. This overall capability value was an average of the relative order established by the average of CVk and the sum of CVk for the merged issues.

Step 7. The list of capability issues ordered by the multiple attribute decision tree technique received an initial review by the CCCA, CCH, and CCL Study Directors before being finalized for presentation to the CCCA General Officer Steering Committee (GOSC).

VII. Mechanics.

All calculations and data manipulation were accomplished using the LOTUS 1-2-3 spreadsheet software. What follows is an explanation of the process of gathering data, translating it into a format compatible with the analytical methodology, developing spreadsheet files and macros to manipulate the data and calculate the values required to produce an ordered list of issues. This will be the most lengthy section of the paper, and as such will serve the reader best if it is divided into subsections.

A. Data Collection.

Due to the classified nature of the end-product of this prioritization methodology, data elements are not described in detail, and most variable designations have been changed.

The first input data required was the ordering and valuation of the seven theater/echelon/threat combinations. This was

accomplished during a decision briefing to the CAC and CACDA Commanders in April 1988. This valuation is given below:

Theater/Echelon/Threat	Order	Value
TE1	1	90
TE2	2	70
TE3	3	60
TE4	4	40
TE5	5	30
TE6	6	25
TE7	7	20

The ordering indicates which theater/echelon/threat combination is most important in terms of battlefield capability while the valuation shows how much more important one combination is than another. For example, TE1 is judged to be approximately 1.29 times as important as TE2 while it is judged 4.5 times as important as TE7, not the 2 times and 7 times that simple ordering would indicate. Thus, while it has been judged that one TEi is more important than another, the magnitude of difference in importance is relatively small. The ordering and valuation of the TEi was done at the General Officer level because of the need for an executive level overview of the Army mission.

The remaining data required was provided in reports from the CCCA, CCH, and CCL study teams. The reports were produced in two parts, Part I Battlefield Requirements/Associated Task Input and Part II Degradation/Enhancement Input.

The Close Combat Capability Analysis (CCCA) Prioritization Methodology Inputs Memorandum of Instruction (MOI) outlined the inputs required to provide a foundation for prioritizing the

capability issues identified by the study teams. The initial submission from the study teams was an ordering and valuation of the battlefield requirements and associated Blueprint of the Battlefield tasks by theater/echelon/threat. The guidance that was given to assist the study teams in preparing this Battlefield Requirements/Associated Task Input follows.

> 1. ... Each ordered battlefield requirement is to be assigned a value on a scale of 0 to 100. This will establish a relative ranking of the battlefield requirements ... . In the same manner the essential Blueprint of the Battlefield tasks associated with each BR are to be assigned a value on a scale of 0 to 100. Procedures are outlined in paragraphs 2 and 3 below.
>
> 2. Battlefield Requirements.
>
> a. Ordering of Battlefield Requirements - Order each battlefield requirement according to its importance to the echelon/theater being considered. ...
>
> b. Valuing Battlefield Requirements - Assign a value to each ordered battlefield requirement on a scale of 0 to 100 to establish a relative ranking.
>
> 3. Blueprint of the Battlefield Tasks.
>
> a. Essential Tasks - Consider all Blueprint of the Battlefield tasks for each battlefield requirement. Determine those tasks essential to the successful accomplishment of the battlefield requirement. ...
>
> b. Valuing Associated Tasks - Assign a value to each essential task on a scale of 1 [sic] to 100 to establish a relative ranking according to its importance to the accomplishment of the associated battlefield requirement with respect to the theater/echelon being considered. [16]

[16] USCACDA, (ATZL-CAI-I) Memo, Subject: CCCA Prioritization Methodology Inputs MOI Encl 3, Battlefield Requirements/Associated Tasks Input, 22 April 1988, p.1.

An example of the proposed report format for the Battlefield Requirements/Associated Tasks Input is shown in Table 3. The organization of the study teams and the distribution of responsibilities for analysis of the seven theater/echelon/threat combinations resulted in a separate report for each TEi.

EXAMPLE

PART I

BATTLEFIELD REQUIREMENTS/ASSOCIATED TASKS INPUT

(Theater/Echelon) *(Study Team)*

BFD REQ (Order-Value):

BOS	*TASK NUMBER (VALUE)*
BFD REQ (1 - 90): BRa1	
Maneuver (MAN)	1.1.1.1.1 (80), 1.1.1.1.2 (75), 1.1.1.2 (82), 1.2.1.1.1 (67), ...
Fire Support (FS)	2.1.1 (91), 2.1.2.1 (77), 2.1.2.2 (93), ...
Air Defense (AD)	3.1.1 (89), 3.1.2.1 (60), ...
Command and Control (CC)	4.1.1.1 (78), 4.1.1.2 (85), ...
Intelligence (INT)	5.1.1.1 (80), 5.1.1.2 (90), ...
Mobility and Survivability	6.1.1.1.1 (79), 6.1.1.1.2 (75), ...
Combat Service Support (CSS)	7.2.2.1 (88), 7.2.2.2 (75), 7.2.2.3 (39), ...
BFD REQ (2 - 78): BRa2	
Maneuver (MAN)	1.1.1.1.1 (90), 1.1.1.1.2 (75), 1.1.1.2 (82), ... 1.2.1.1.1 (67)
Fire Support (FS)	2.1.1 (81), 2.1.2.1 (77), 2.1.2.2 (93), ...
Air Defense (AD)	3.1.1 (89), 3.1.2.1 (89), ...
Command and Control (CC)	4.1.1.1 (88), 4.1.1.2 (95), ...

Table 3. [17]

[17] USCACDA, (ATZL-CAI-I) Memo, Subject: CCCA Prioritization Methodology Inputs MOI Encl 3, 22 April 1988, p.12.

The final prioritization submission from the study teams was the Part II Degradation/Enhancement Input report. This report provided a valuation of the deficiencies and efficiencies identified during analysis. The guidance provided for preparing this report follows.

> 1. Each issue (deficiency/efficiency) will be valued on a scale from 0 to 100 relative to the amount of degradation/enhancement of the capability to accomplish the associated battlefield requirement with respect to the theater/echelon being considered.
>
> 2. While deficiencies fall neatly into categories, the categorization of efficiencies is not so clearly defined in TRADOC literature. The following definitions should be given consideration when assigning values to the issues.
>
> a. Deficiency - An inability or inadequacy in the performance of a task that is essential to the successful accomplishment of a battlefield requirement. An inability is further defined as the total lack of capability to perform the task. An inadequacy exists when some capability to perform the tasks exists. Inadequacies may be further grouped as severe, moderate, or minor in nature, where a severe inadequacy would have a significant impact on the accomplishment of a mission while a minor inadequacy would have less impact, but over time may be a detriment to the desired level of success.
>
> b. Efficiency - An opportunity to enhance Blue [U.S. Forces] potential in order to exploit a threat capability (may or may not be a threat vulnerability). Will allow Blue to gain a decided advantage. [18]

An example of the proposed format for this final report is shown in Table 4.

[18] USCACDA, (ATZL-CAI-I) Memo, Subject: CCCA Prioritization Methodology Inputs MOI Encl 4, 22 April 1988, p.1.

EXAMPLE (Study Team)
PART II
DEGRADATION/ENHANCEMENT VALUATION

ISSUE: Inadequate ability ...

RELATED TASK: 5.1.2.3

BATTLEFIELD REQUIREMENT	THEATER/ECHELON	VALUATION
BRa1	TE1	8 3
BRa2	TE1	7 6
BRa3	TE1	9 8
BRa4	TE1	5 9
BRa6	TE1	7 6
BRa8	TE1	8 7
BRa1	TE2	8 0
BRa2	TE2	7 6
BRa3	TE2	5 8
BRa4	TE2	9 9
BRa6	TE2	8 6
BRa8	TE2	7 7

Table 4. [19]

All the raw data collected was entered into a master spreadsheet file. This master spreadsheet file was used to provide the data required to build all subsequent spreadsheets necessary to complete the capability value computations.

[19] USCACDA, (ATZL-CAI-I) Memo, Subject: CCCA Prioritization Methodology Inputs MOI Encl 4, 22 April 1988, p.2.

B. Translation of Values.

The data received in response to the CCCA Prioritization Methodology Inputs MOI required translation into a format compatible with the assumption that the sum of the values for branches from a node of the tree will be equal to one. Two approaches were used to translate the raw data values to a compatible format.

The theater/echelon/threat and battlefield requirements values were easily translated by normalizing each value on a proportional basis within its group. That is, each value in a group was divided by the sum of the values in the group. The results of this translation exercise are given below.

THEATER/ ECHELON/ THREAT	RAW VALUE	TRANSLATED VALUE
TE1	90.0000	0.2686567164
TE2	70.0000	0.2089552239
TE3	60.0000	0.1791044776
TE4	40.0000	0.1194029851
TE5	30.0000	0.0895522388
TE6	25.0000	0.0746268657
TE7	20.0000	0.0597014925
Total	335.0000	1.0000000000

BATTLEFIELD REQUIREMENT	RAW VALUE	TRANSLATED VALUE
BRa1	100.0000	0.1515151515
BRa2	90.0000	0.1363636364
BRa3	85.0000	0.1287878788
BRa4	80.0000	0.1212121212
BRa5	70.0000	0.1060606061

BATTLEFIELD REQUIREMENT	RAW VALUE	TRANSLATED VALUE
BRa6	65.0000	0.0984848485
BRa7	65.0000	0.0984848485
BRa8	55.0000	0.0833333333
BRa9	50.0000	0.0757575758
Total	660.0000	1.0000000000
BRb1	100.0000	0.1242236025
BRb2	95.0000	0.1180124224
BRb3	90.0000	0.1118012422
BRb4	80.0000	0.0993788820
BRb5	75.0000	0.0931677019
BRb6	80.0000	0.0993788820
BRb7	80.0000	0.0993788820
BRb8	70.0000	0.0869565217
BRb9	65.0000	0.0807453416
BRb10	70.0000	0.0869565217
Total	805.0000	1.0000000000
BRc1	100.0000	0.1941747573
BRc2	95.0000	0.1844660194
BRc3	90.0000	0.1747572816
BRc4	70.0000	0.1359223301
BRc5	65.0000	0.1262135922
BRc6	35.0000	0.0679611650
BRc7	40.0000	0.0776699029
BRc8	20.0000	0.0388349515
Total	515.0000	1.0000000000
BRd1	100.0000	0.2053388090
BRd2	98.0000	0.2012320329
BRd3	97.0000	0.1991786448
BRd4	96.0000	0.1971252567
BRd5	96.0000	0.1971252567
Total	487.0000	1.0000000000
BRe1	100.0000	0.2272727273
BRe2	90.0000	0.2045454545
BRe3	90.0000	0.2045454545
BRe4	80.0000	0.1818181818
BRe5	80.0000	0.1818181818
Total	440.0000	1.0000000000

BATTLEFIELD REQUIREMENT	RAW VALUE	TRANSLATED VALUE
BRf1	100.0000	0.2079002079
BRf2	97.0000	0.2016632017
BRf3	97.0000	0.2016632017
BRf4	95.0000	0.1975051975
BRf5	92.0000	0.1912681913
Total	481.0000	1.0000000000
BRg1	100.0000	0.2272727273
BRg2	90.0000	0.2045454545
BRg3	90.0000	0.2045454545
BRg4	80.0000	0.1818181818
BRg5	80.0000	0.1818181818
Total	440.0000	1.0000000000

Translation of the third and fourth attribute values was not as easily accomplished. It was obvious from the raw data collected that there was a sizeable difference in the number of tasks being valued per battlefield requirement. The senior leadership became concerned that the results would be skewed in favor of a task from a small group when it was not realistically as important as it might be found to be by the numbers. For example, a task valued at 100 under a highly valued theater/echelon/threat combination and a highly valued battlefield requirement could have a calculated task value (TVk) less than a task valued 70 in less exalted circumstances if the latter task came from a smaller number of tasks with a smaller total group value. Suppose that task T1 is valued 100 under TE1 (valued 90) and BRa1 (valued 100), while T10 is valued 70 under TE2 (valued 70) and BRb1 (valued 100), then

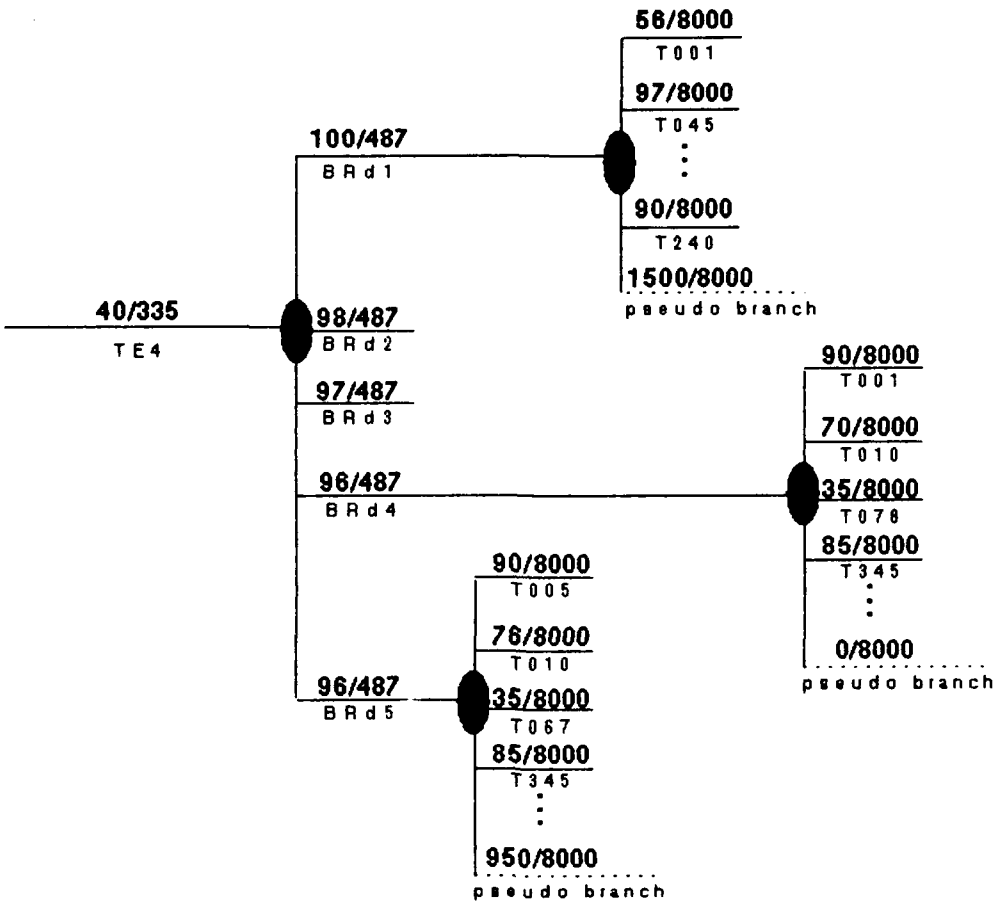
TVT1 = (TE1)(BRa1)(T1) = (90/335)(100/660)(100/8000) = .0005088

and

TVT10 = (TE2)(BRb1)(T10) = (70/335)(100/515)(70/5000) = .0005680.

It appears mathematically that T10 is more important than T1 because it has a greater TVk, when realistically this may not be the case. In order to allay this concern, it was decided the best approach would be to consider a particular value to have the same translated value no matter where or by whom it had been assigned. The largest total of all assigned task value groups was chosen to be the denominator for normalizing the task values. In order to satisfy the requirement that the sum of the values on the branches from a node equal one, a pseudo branch representing the non-selected tasks was added to each node to "take up the slack." For example, if the largest sum of task values for all the battlefield requirements was 8000, then it would be the denominator used to normalize the task values. For the group whose total was 8000, the pseudo branch would have the value zero, while another group with summed task values equalling 6500 would have a pseudo branch whose value would be (8000 - 6500)/8000. An illustration is provided in Figure 9. The pseudo branch from a node is a convention to the theory and does not become a factor in the computational steps.

The translation of the degradation/enhancement values was accomplished in the same manner as the translation of task values, however the denominator, while chosen in the same manner, differed in each case. The approach used for translating the



Pseudo Branch in Task Value Translation
Figure 9.

values for these last two attributes is supported by the observation that the average of the values assigned by the various study teams fell in a relatively narrow range. It makes sense in this context for equal values, regardless of origin, to have equal translation values. The translated values for the tasks and issues are given below.

TASK IMPORTANCE		DEGRADATION/ENHANCEMENT	
RAW VALUE	TRANSLATED VALUE	RAW VALUE	TRANSLATED VALUE
100.0000	0.0113765643	100.0000	0.0113507378
99.0000	0.0112627986	99.0000	0.0112372304
98.0000	0.0111490330	98.0000	0.0111237230
97.0000	0.0110352673	97.0000	0.0110102157

TASK IMPORTANCE		DEGRADATION/ENHANCEMENT	
RAW VALUE	TRANSLATED VALUE	RAW VALUE	TRANSLATED VALUE
96.0000	0.0109215017	96.0000	0.0108967083
95.0000	0.0108077361	95.0000	0.0107832009
94.0000	0.0106939704	94.0000	0.0106696935
93.0000	0.0105802048	93.0000	0.0105561862
92.0000	0.0104664391	92.0000	0.0104426788
91.0000	0.0103526735	91.0000	0.0103291714
90.0000	0.0102389078	90.0000	0.0102156640
89.0000	0.0101251422	89.0000	0.0101021566
88.0000	0.0100113766	88.0000	0.0099886493
87.0000	0.0098976109	87.0000	0.0098751419
86.0000	0.0097838453	86.0000	0.0097616345
85.0000	0.0096700796	85.0000	0.0096481271
84.0000	0.0095563140	84.0000	0.0095346198
83.0000	0.0094425484	83.0000	0.0094211124
82.0000	0.0093287827	82.0000	0.0093076050
81.0000	0.0092150171	81.0000	0.0091940976
80.0000	0.0091012514	80.0000	0.0090805902
79.0000	0.0089874858	79.0000	0.0089670829
78.0000	0.0088737201	78.0000	0.0088535755
77.0000	0.0087599545	77.0000	0.0087400681
76.0000	0.0086461889	76.0000	0.0086265607
75.0000	0.0085324232	75.0000	0.0085130533
74.0000	0.0084186576	74.0000	0.0083995460
73.0000	0.0083048919	73.0000	0.0082860386
72.0000	0.0081911263	72.0000	0.0081725312
71.0000	0.0080773606	71.0000	0.0080590238
70.0000	0.0079635950	70.0000	0.0079455165
69.0000	0.0078498294	69.0000	0.0078320091
68.0000	0.0077360637	68.0000	0.0077185017
67.0000	0.0076222981	67.0000	0.0076049943
66.0000	0.0075085324	66.0000	0.0074914869
65.0000	0.0073947668	65.0000	0.0073779796
64.0000	0.0072810011	64.0000	0.0072644722
63.0000	0.0071672355	63.0000	0.0071509648
62.0000	0.0070534699	62.0000	0.0070374574
61.0000	0.0069397042	61.0000	0.0069239501
60.0000	0.0068259386	60.0000	0.0068104427
59.0000	0.0067121729	59.0000	0.0066969353
58.0000	0.0065984073	58.0000	0.0065834279
57.0000	0.0064846416	57.0000	0.0064699205
56.0000	0.0063708760	56.0000	0.0063564132
55.0000	0.0062571104	55.0000	0.0062429058
54.0000	0.0061433447	54.0000	0.0061293984
53.0000	0.0060295791	53.0000	0.0060158910
52.0000	0.0059158134	52.0000	0.0059023837
51.0000	0.0058020478	51.0000	0.0057888763
50.0000	0.0056882821	50.0000	0.0056753689

TASK IMPORTANCE		DEGRADATION/ENHANCEMENT	
RAW VALUE	TRANSLATED VALUE	RAW VALUE	TRANSLATED VALUE
49.0000	0.0055745165	49.0000	0.0055618615
48.0000	0.0054607509	48.0000	0.0054483541
47.0000	0.0053469852	47.0000	0.0053348468
46.0000	0.0052332196	46.0000	0.0052213394
45.0000	0.0051194539	45.0000	0.0051078320
44.0000	0.0050056883	44.0000	0.0049943246
43.0000	0.0048919226	43.0000	0.0048808173
42.0000	0.0047781570	42.0000	0.0047673099
41.0000	0.0046643914	41.0000	0.0046538025
40.0000	0.0045506257	40.0000	0.0045402951
39.0000	0.0044368601	39.0000	0.0044267877
38.0000	0.0043230944	38.0000	0.0043132804
37.0000	0.0042093288	37.0000	0.0041997730
36.0000	0.0040955631	36.0000	0.0040862656
35.0000	0.0039817975	35.0000	0.0039727582
34.0000	0.0038680319	34.0000	0.0038592509
33.0000	0.0037542662	33.0000	0.0037457435
32.0000	0.0036405006	32.0000	0.0036322361
31.0000	0.0035267349	31.0000	0.0035187287
30.0000	0.0034129693	30.0000	0.0034052213
29.0000	0.0032992036	29.0000	0.0032917140
28.0000	0.0031854380	28.0000	0.0031782066
27.0000	0.0030716724	27.0000	0.0030646992
26.0000	0.0029579067	26.0000	0.0029511918
25.0000	0.0028441411	25.0000	0.0028376844
24.0000	0.0027303754	24.0000	0.0027241771
23.0000	0.0026166098	23.0000	0.0026106697
22.0000	0.0025028441	22.0000	0.0024971623
21.0000	0.0023890785	21.0000	0.0023836549
20.0000	0.0022753129	20.0000	0.0022701476
19.0000	0.0021615472	19.0000	0.0021566402
18.0000	0.0020477816	18.0000	0.0020431328
17.0000	0.0019340159	17.0000	0.0019296254
16.0000	0.0018202503	16.0000	0.0018161180
15.0000	0.0017064846	15.0000	0.0017026107
14.0000	0.0015927190	14.0000	0.0015891033
13.0000	0.0014789534	13.0000	0.0014755959
12.0000	0.0013651877	12.0000	0.0013620885
11.0000	0.0012514221	11.0000	0.0012485812
10.0000	0.0011376564	10.0000	0.0011350738

No value less than 10 was assigned for either a task value or a degradation/enhancement value.

C. File Format.

Two factors had an impact on the design of the spreadsheet files. The first was the necessity of tracking each individual path along connecting branches of the decision tree. This had to be done to tie the attributes together along each unique path from beginning to end. The second was the sheer magnitude of the data that required manipulation, translation, and computation.

The latter factor required that seven separate files be built for each stage in the process. In addition, it was necessary to build a series of files that stepped through the computation process so that it would be possible to change values at any stage of the process, if called upon to do so, or more important to be able to trace the process of obtaining a particular value. Outside constraints of the software spreadsheet memory capacity and the hardware storage capacity also became driving factors in limiting the size of spreadsheets, and increasing the total number of files required. Awareness of the necessity for this multiple spreadsheet file approach to preparing the software to execute the multiple attribute decision tree technique came early in the process. The first attempt to extract data from the raw data file into a single computational spreadsheet file failed due to the size limitations cited.

The precise layout of the spreadsheet was dictated by the first factor discussed. In order to identify each unique path on the multiple attribute decision tree, each segment of the connected branches had to be identified. Each spreadsheet had to contain identifiers for the TEi, BRj, task and/or issue, TVk and/or DEk, and CVk, as appropriate. A sample of the layout for the first set of spreadsheet files, the TET# (where # goes from 1 to 7), is shown in Table 5. While the layout of these spreadsheet files may appear trivial, their role in the total software system is of immeasurable importance. The magnitude of the effort to build

	A	B	C	D	...	AA	AB	AC	AD
1	TEi	BRj	TASK	TASK IMP		TASK	BRa1	BRa2	BRa3
2	TEi	BRa1	1.1.1.1.1	90		1.1.1 A	0	0	0
3	TEi	BRa1	1.1.1.1.2	90		1.1.1.1 A	0	60	80
4	TEi	BRa1	1.1.1.2	70		1.1.1.1.1	90	70	90
5	TEi	BRa1	1.1.2	60		1.1.1.1.2	90	50	50
6	TEi	BRa1	1.1.3	100		1.1.1.2	70	1	80
7	TEi	BRa1	1.1.4	40		1.1.2	60	1	1
8	TEi	BRa1	1.2.1.1.1	90		1.1.3	100	80	50
9	TEi	BRa1	1.2.1.1.2	70		1.1.4	40	1	1
10	TEi	BRa1	1.2.1.2	100		1.2.1 A	0	0	0
11	TEi	BRa1	1.3.1	80		1.2.1.1.1	90	90	1
12	TEi	BRa1	1.3.2	80		1.2.1.1.2	70	80	1
13	TEi	BRa1	2.1.1	100		1.2.1.2	100	100	40
14	TEi	BRa1	2.1.2.1	50		1.3.1	80	90	1
15	TEi	BRa1	2.1.2.2	60		1.3.2	80	1	1
16	TEi	BRa1	2.1.2.3	70		2.1.1	100	100	1
17	TEi	BRa1	2.2.1.1	100		2.1.2.1	50	60	1
18	TEi	BRa1	2.2.1.2	90		2.1.2.2	60	60	1
19	TEi	BRa1	2.2.1.3	90		2.1.2.3	70	80	1
20	TEi	BRa1	2.2.2.1.1	50		2.2.1.1	100	100	40
21	TEi	BRa1	2.2.2.1.2	10		2.2.1.2	90	70	1
22	TEi	BRa1	2.2.2.2.1	60		2.2.1.3	90	80	1
23	TEi	BRa1	2.2.2.2.2	100		2.2.2.1.1	50	70	1
24	TEi	BRa1	3.1.1	80		2.2.2.1.2	10	30	1
25	TEi	BRa1	3.1.2.1	50		2.2.2.2.1	60	40	1
26	TEi	BRa1	3.1.2.2	60		2.2.2.2.2	100	0	0
27	TEi	BRa1	3.1.2.3	70		3.1.1	80	80	1

Sample of TET1.WK1 Spreadsheet Format
Table 5.

the files required will become apparent in the section outlining the macros (programs) which would have been impossible without standardization in spreadsheet formats.

The TET#.WK1 spreadsheet files were derived from the data inputs contained in the raw data file. Their purpose was to align the data in a format that would simplify the translation of task values, as well as providing a file that would allow quick retrieval of specific data items, e.g., task importance for a particular path on the decision tree. The data in these files was sorted by battlefield requirement.

Translation of task importance values was accomplished and stored in a set of seven spreadsheet files designated TI-#.WK1. The format established a file that could be directly imported into a spreadsheet for computational purposes. A sample of the format for these spreadsheets is shown in Table 6. The data in the TI-#.WK1 spreadsheet file was also sorted by battlefield requirement.

	A	B	C	D
1	TE1	BRj	TASK	TASK IMPORTANCE
2	TE1	BRa1	1.1.1.1.1	0.0102389078
3	TE1	BRa1	1.1.1.1.2	0.0102389078
4	TE1	BRa1	1.1.1.2	0.0079635950
5	TE1	BRa1	1.1.2	0.0068259386
6	TE1	BRa1	1.1.3	0.0113765643
7	TE1	BRa1	1.1.4	0.0045506257
8	TE1	BRa1	1.2.1.1.1	0.0102389078
9	TE1	BRa1	1.2.1.1.2	0.0079635950
10	TE1	BRa1	1.2.1.2	0.0113765643

11	TE1	BRa1	1.3.1	0.0091012514
12	TE1	BRa1	1.3.2	0.0091012514
13	TE1	BRa1	2.1.1	0.0113765643
14	TE1	BRa1	2.1.2.1	0.0056882821
15	TE1	BRa1	2.1.2.2	0.0068259386
16	TE1	BRa1	2.1.2.3	0.0079635950
17	TE1	BRa1	2.2.1.1	0.0113765643
18	TE1	BRa1	2.2.1.2	0.0102389078
19	TE1	BRa1	2.2.1.3	0.0102389078
20	TE1	BRa1	2.2.2.1.1	0.0056882821
21	TE1	BRa1	2.2.2.1.2	0.0011376564
22	TE1	BRa1	2.2.2.2.1	0.0068259386
23	TE1	BRa1	2.2.2.2.2 A	0.0113765643
24	TE1	BRa1	3.1.1	0.0091012514
25	TE1	BRa1	3.1.2.1	0.0056882821
26	TE1	BRa1	3.1.2.2	0.0068259386
27	TE1	BRa1	3.1.2.3	0.0079635950
28	TE1	BRa1	3.2.1.1	0.0102389078
29	TE1	BRa1	3.2.1.2.1	0.0113765643
30	TE1	BRa1	3.2.1.2.2	0.0056882821
31	TE1	BRa1	3.2.2	0.0068259386
32	TE1	BRa1	3.3	0.0091012514
33	TE1	BRa1	4.1.1 A	0.0113765643
34	TE1	BRa1	4.1.1.1	0.0113765643
35	TE1	BRa1	4.1.1.2	0.0113765643

Sample of TI-1.WK1 Spreadsheet Format
Table 6.

Task value (TVk) was calculated and stored in the TVK#.WK1 spreadsheet files. Once the calculation were completed, the data was sorted first by Blueprint of the Battlefield tasks and second by battlefield requirements. This sorting allowed for the grouping of data and an interim calculation of an average TVk which made it possible to derive an ordered list of essential tasks. This was the first example of the output that was possible from the multiple attribute decision tree technique. The list of ordered essential tasks that resulted is provided in Appendix D. The format of the TVK#.WK1 spreadsheet files is shown in Table 7.

	A	B	C	D
1	TEi	BRj	TASK	TVk
2	TE1	BRa1	1.1.1.1.1	0.0004167805
3	TE1	BRa1	1.1.1.1.2	0.0004167805
4	TE1	BRa1	1.1.1.2	0.0003241626
5	TE1	BRa1	1.1.2	0.0002778537
6	TE1	BRa1	1.1.3	0.0004630895
7	TE1	BRa1	1.1.4	0.0001852358
8	TE1	BRa1	1.2.1.1.1	0.0004167805
9	TE1	BRa1	1.2.1.1.2	0.0003241626
10	TE1	BRa1	1.2.1.2	0.0004630895
11	TE1	BRa1	1.3.1	0.0003704716
12	TE1	BRa1	1.3.2	0.0003704716
13	TE1	BRa1	2.1.1	0.0004630895
14	TE1	BRa1	2.1.2.1	0.0002315447
15	TE1	BRa1	2.1.2.2	0.0002778537
16	TE1	BRa1	2.1.2.3	0.0003241626
17	TE1	BRa1	2.2.1.1	0.0004630895
18	TE1	BRa1	2.2.1.2	0.0004167805
19	TE1	BRa1	2.2.1.3	0.0004167805
20	TE1	BRa1	2.2.2.1.1	0.0002315447
21	TE1	BRa1	2.2.2.1.2	0.0000463089
22	TE1	BRa1	2.2.2.2.1	0.0002778537
23	TE1	BRa1	2.2.2.2.2 A	0.0004630895
24	TE1	BRa1	3.1.1	0.0003704716
25	TE1	BRa1	3.1.2.1	0.0002315447

Sample of TVK1.WK1 Spreadsheet Format
Table 7.

The DET#.WK1 spreadsheet files are similar in format to the TET#.WK1 spreadsheet files with one significant exception. It is necessary to identify the issues identified during analysis as either deficiencies or efficiencies, and to track it origin, that is, which of the three study teams identified it as an issue. This was accomplished by adding two columns to the spreadsheet format constructed for the TET#.WK1 spreadsheet files. The formats for the DE-#.WK1 and DEK#.WK1 spreadsheet files differ from their task file counterparts in the same manner. Samples of the formats for the DET1.WK1, DE-1.WK1, and DEK1.WK1 spreadsheet files are shown in Tables 8, 9, and 10, respectively.

	A	B	C	D	E	F	...	AA	AB	AC	AD	AE
1	TE1	BRj	D/E	ID	TASK	D/E VAL	...	TASK	D/E	ID	BRa1	BRa2
2	TE1	BRa1	D	a1	1.1.1.1.1	70		1.1.1.1 A	D	a4		10
3	TE1	BRa1	D	a2	1.1.1.1.1	30		1.1.1.1.1	D	a1	70	70
4	TE1	BRa1	D	a3	1.1.1.2	10		1.1.1.1.1	D	a3		
5	TE1	BRa1	D	a7	1.1.1.2	10		1.1.1.1.1	D	a2	30	30
6	TE1	BRa1	D	a8	1.1.1.2	30		1.1.1.1.2	D	a5		60
7	TE1	BRa1	D	a10	1.1.3	20		1.1.1.2	D	a6	10	30
8	TE1	BRa1	D	a11	1.1.3	10		1.1.1.2	D	a7	10	10
9	TE1	BRa1	D	a12	1.1.3	10		1.1.1.2	D	a8	30	60
10	TE1	BRa1	D	a194	1.1.3	60		1.1.1.2	D	a9		50
11	TE1	BRa1	D	a13	1.1.4	20		1.1.3	D	a10	20	
12	TE1	BRa1	D	a14	1.2.1.1.1	60		1.1.3	D	a11	10	10
13	TE1	BRa1	D	a15	1.2.1.2	20		1.1.3	D	a12	10	10
14	TE1	BRa1	D	a16	1.2.1.2	70		1.1.3	D	a194	60	
15	TE1	BRa1	D	a17	1.2.1.2	70		1.1.4	D	a13	20	
16	TE1	BRa1	D	a18	1.2.1.2	70		1.2.1.1.1	D	a14	60	80
17	TE1	BRa1	D	a19	1.2.1.2	70		1.2.1.2	D	a15	20	20
18	TE1	BRa1	D	a20	1.2.1.2	90		1.2.1.2	D	a16	70	20
19	TE1	BRa1	D	a21	1.2.1.2	70		1.2.1.2	D	a17	70	20
20	TE1	BRa1	D	a22	2.1.1	60		1.2.1.2	D	a18	70	20
21	TE1	BRa1	D	a23	2.2.1.1	90		1.2.1.2	D	a19	70	70
22	TE1	BRa1	D	a24	2.2.1.1	70		1.2.1.2	D	a20	90	10

Sample of DET1.WK1 Spreadsheet Format
Table 8.

	A	B	C	D	E	F
1	TE1	BRj	D/E	ID	TASK	D/E VALUE
2	TE1	BRa1	D	a1	1.1.1.1.1	0.0079455165
3	TE1	BRa1	D	a2	1.1.1.1.1	0.0034052213
4	TE1	BRa1	D	a6	1.1.1.2	0.0011350738
5	TE1	BRa1	D	a7	1.1.1.2	0.0011350738
6	TE1	BRa1	D	a8	1.1.1.2	0.0034052213
7	TE1	BRa1	D	a10	1.1.3	0.0022701476
8	TE1	BRa1	D	a11	1.1.3	0.0011350738
9	TE1	BRa1	D	a12	1.1.3	0.0011350738
10	TE1	BRa1	D	a194	1.1.3	0.0068104427
11	TE1	BRa1	D	a13	1.1.4	0.0022701476
12	TE1	BRa1	D	a14	1.2.1.1.1	0.0068104427
13	TE1	BRa1	D	a15	1.2.1.2	0.0022701476
14	TE1	BRa1	D	a16	1.2.1.2	0.0079455165
15	TE1	BRa1	D	a17	1.2.1.2	0.0079455165
16	TE1	BRa1	D	a18	1.2.1.2	0.0079455165
17	TE1	BRa1	D	a19	1.2.1.2	0.0079455165
18	TE1	BRa1	D	a20	1.2.1.2	0.0102156640
19	TE1	BRa1	D	a21	1.2.1.2	0.0079455165
20	TE1	BRa1	D	a22	2.1.1	0.0068104427

Sample of DE-1.WK1 Spreadsheet Format
Table 9.

	A	B	C	D	E	F
1	TEi	BRj	D/E	ID	TASK	DEk
2	TE1	BRa1	D	a1	1.1.1.1.1	0.0003234267
3	TE1	BRa1	D	a2	1.1.1.1.1	0.0001386115
4	TE1	BRa1	D	a6	1.1.1.2	0.0000462038
5	TE1	BRa1	D	a7	1.1.1.2	0.0000462038
6	TE1	BRa1	D	a8	1.1.1.2	0.0001386115
7	TE1	BRa1	D	a10	1.1.3	0.0000924076
8	TE1	BRa1	D	a11	1.1.3	0.0000462038
9	TE1	BRa1	D	a12	1.1.3	0.0000462038
10	TE1	BRa1	D	a194	1.1.3	0.0002772229
11	TE1	BRa1	D	a13	1.1.4	0.0000924076
12	TE1	BRa1	D	a14	1.2.1.1.1	0.0002772229
13	TE1	BRa1	D	a15	1.2.1.2	0.0000924076
14	TE1	BRa1	D	a16	1.2.1.2	0.0003234267
15	TE1	BRa1	D	a17	1.2.1.2	0.0003234267
16	TE1	BRa1	D	a18	1.2.1.2	0.0003234267
17	TE1	BRa1	D	a19	1.2.1.2	0.0003234267
18	TE1	BRa1	D	a20	1.2.1.2	0.0004158344
19	TE1	BRa1	D	a21	1.2.1.2	0.0003234267
20	TE1	BRa1	D	a22	2.1.1	0.0002772229
21	TE1	BRa1	D	a23	2.2.1.1	0.0004158344

Sample of DEK1.WK1 Spreadsheet Format
Table 10.

Once all the data was received and input, and the task and degradation/enhancement spreadsheet files built, the process of calculating the capability value for each issue began. Seven spreadsheet files, designated CVK#-SA.WK1, were built to compute capability values and provide a method for comparing the impact of various weighting factors. A Sample of the CVK1-SA.WK1 spreadsheet file is shown in Table 11. The CVK#-SA.WK1 files were subdivided into smaller spreadsheet files to facilitate the sensitivity analysis of the various weighting factors being considered. Formats were rigidly maintained. The smaller spreadsheet files were designated CVK#-64.WK1, CVK#-55.WK1, CVK#-46.WK1, and CVK#-37.WK1, where # takes values from 1 to 7. The last two digits in the file name indicate the weighting factors,

	A	B	C	D	E	F	G	H
1	TEi	BRj	TASK	TVk		D/E	ID	DEk
2	TE1	BRa2	1.1.1.1 A	0.0002500683		D	a4	0.0000415834
3	TE1	BRa3	1.1.1.1 A	0.0003149008		D	a4	0.0000392732
4	TE1	BRa4	1.1.1.1 A	0.0001481866		D	a4	0.0000369631
5	---	---	---	---		---	---	---
6	TE1	BRa1	1.1.1.1.1	0.0004167805		D	a1	0.0003234267
7	TE1	BRa1	1.1.1.1.1	0.0004167805		D	a2	0.0001386115
8	TE1	BRa2	1.1.1.1.1	0.0002917464		D	a2	0.0001247503
9	TE1	BRa2	1.1.1.1.1	0.0002917464		D	a1	0.0002910840
10	TE1	BRa3	1.1.1.1.1	0.0003542634		D	a2	0.0000785465
11	TE1	BRa3	1.1.1.1.1	0.0003542634		D	a1	0.0002749127
12	TE1	BRa4	1.1.1.1.1	0.0001116495		D	a3	0.0001108892
13	TE1	BRa5	1.1.1.1.1	0.0002917464		D	a3	0.0000970280
14	TE1	BRa5	1.1.1.1.1	0.0002917464		D	a2	0.0000323427
15	TE1	BRa7	1.1.1.1.1	0.0002709073		D	a2	0.0000300325
16	TE1	BRa7	1.1.1.1.1	0.0002709073		D	a3	0.0000900974
17	TE1	BRa9	1.1.1.1.1	0.0000465206		D	a3	0.0001155095
18	---	---	---	---		---	---	---
19	TE1	BRa2	1.1.1.1.2	0.0002083903		D	a5	0.0002495006
20	TE1	BRa3	1.1.1.1.2	0.0001968130		D	a5	0.0001963662
21	TE1	BRa4	1.1.1.1.2	0.0001488661		D	a5	0.0001108892

...	I	J	K	L
	60%-40% CVk	50%-50% CVk	40%-60% CVk	30%-70% CVk
	0.0001666744	0.0001458259	0.0001249774	0.0001041289
	0.0002046498	0.0001770870	0.0001495243	0.0001219615
	0.0001036984	0.0000925758	0.0000814533	0.0000703307
	0.0003794390	0.0003701036	0.0003607682	0.0003514329
	0.0003055129	0.0002776960	0.0002498791	0.0002220622
	0.0002249479	0.0002082483	0.0001915487	0.0001748491
	0.0002914814	0.0002914152	0.0002913490	0.0002912827
	0.0002439767	0.0002164050	0.0001888333	0.0001612616
	0.0003225231	0.0003145881	0.0003066530	0.0002987179
	0.0001113454	0.0001112694	0.0001111933	0.0001111173
	0.0002138590	0.0001943872	0.0001749154	0.0001554435
	0.0001879849	0.0001620445	0.0001361041	0.0001101638
	0.0001745574	0.0001504699	0.0001263824	0.0001022949
	0.0001985834	0.0001805024	0.0001624214	0.0001443404
	0.0000741162	0.0000810151	0.0000879140	0.0000948129
	0.0002248344	0.0002289454	0.0002330565	0.0002371675
	0.0001966343	0.0001965896	0.0001965449	0.0001965003
	0.0001336753	0.0001298776	0.0001260799	0.0001222822

Sample of CVK1-SA.WK1 spreadsheet Format
Table 11

e.g., 64 indicates a 60% weight for TVk and 40% weight for DEk.

These files were built to calculate the average capability value

of an issue across all battlefield requirements and theater/echelon/threat combinations, i.e., a collection of all branches with like end points. A sample of the CVK1-64.WK1 is shown in Table 12.

	A	B	C	D	E	F	G	H	I
1	TEi	BRj	TASK	TVk		D/E	ID	DEk	CVk
2	TE1	BRa2	1.1.1.1 A	0.0002500683		D	a4	0.0000415834	0.0001666744
3	TE1	BRa3	1.1.1.1 A	0.0003149008		D	a4	0.0000392752	0.0002046498
4	TE1	BRa4	1.1.1.1 A	0.0001481886		D	a4	0.0000369631	0.0001036984
5	----------	--------				--------			
6	TE1	BRa1	1.1.1.1.1	0.0004167805		D	a1	0.0003234267	0.0003794390
7	TE1	BRa1	1.1.1.1.1	0.0004167805		D	a2	0.0001386115	0.0003055129
8	TE1	BRa2	1.1.1.1.1	0.0002917464		D	a2	0.0001247503	0.0002249479
9	TE1	BRa2	1.1.1.1.1	0.0002917464		D	a1	0.0002910840	0.0002914814
10	TE1	BRa3	1.1.1.1.1	0.0003542634		D	a2	0.0000785465	0.0002439767
11	TE1	BRa3	1.1.1.1.1	0.0003542634		D	a1	0.0002749127	0.0003225231
12	TE1	BRa4	1.1.1.1.1	0.0000000000		D	a3	0.0001108892	0.0000443557
13	TE1	BRa5	1.1.1.1.1	0.0002917464		D	a3	0.0000970280	0.0002138590
14	TE1	BRa5	1.1.1.1.1	0.0002917464		D	a2	0.0000323427	0.0001879849
15	TE1	BRa7	1.1.1.1.1	0.0002709073		D	a2	0.0000300325	0.0001745574
16	TE1	BRa7	1.1.1.1.1	0.0002709073		D	a3	0.0000900974	0.0001985834
17	TE1	BRa9	1.1.1.1.1	0.0000000000		D	a3	0.0001155095	0.0000462038
18	----------					--------			

	L	M	N	O	P	Q	R
1	TEi	BRj	TASK	D/E	ID	CVk	AVG CVk
2	TE1	BRa1	1.1.1.1.1	D	a1	0.0003794390	0.0003311479
3	TE1	BRa2	1.1.1.1.1	D	a1	0.0002914814	
4	TE1	BRa3	1.1.1.1.1	D	a1	0.0003225231	
5	-----						
6	TE1	BRa1	1.1.3	D	a10	0.0003148167	0.0002321616
7	TE1	BRa3	1.1.3	D	a10	0.0001495064	
8	-----						
9	TE1	BRa1	5.1.2 A	D	a100	0.0003517798	0.0002906898
10	TE1	BRa2	5.1.2 A	D	a100	0.0003166018	
11	TE1	BRa3	5.1.2 A	D	a100	0.0002990128	
12	TE1	BRa4	5.1.2 A	D	a100	0.0002814238	
13	TE1	BRa6	5.1.2 A	D	a100	0.0002046309	
14	-----						
15	TE1	BRa1	5.1.2 A	D	a101	0.0003332983	0.0003255800
16	TE1	BRa2	5.1.2 A	D	a101	0.0003665019	
17	TE1	BRa3	5.1.2 A	D	a101	0.0003618500	
18	TE1	BRa6	5.1.2 A	D	a101	0.0002406699	
19	-----						

Sample of CVK1-64.WK1 spreadsheet Format
Table 12

The averaged capability values were collected into spreadsheet files designated ORDER-##.WK1, where ## takes the values 64, 55, 46, and 37. An additional spreadsheet file was built to compare the four ordered listing that resulted. This file was called ORDER-SA.WK1. Samples of the ORDER-64.WK1 and the ORDER-SA.WK1 spreadsheet files are shown in Tables 13 and 14, respectively.

ORDER	TASK	D/E	ID	CVk
1	2.2.1.2	D	a39	0.0004348836
2	6.3.1.1.2	D	a146	0.0003794390
3	6.2.2.1	D	a122	0.0003794390
4	5.1.1.1	E	a88	0.0003739907
5	2.2.1.1	D	a23	0.0003664546
6	2.2.1.1	D	a28	0.0003517798
7	2.2.1.1	E	a33	0.0003517482
...				
626	4.1.1 A	D	f32	0.0000267681
627	1.1.1 A	D	c2	0.0000228956
628	7.5.1.2.1	D	f65	0.0000226825
629	2.2.2.1.2	D	c35	0.0000157900

Sample of ORDER-64.WK1 spreadsheet Format
Table 13.

TASK	D/E	ID	60%-40% ORDER	50%-50% ORDER	40%-60% ORDER	30%-70% ORDER
2.2.1.2	D	a39	1	1	1	1
6.3.1.1.2	D	a146	2	3	3	5
6.2.2.1	D	a122	3	4	4	4
5.1.1.1	E	a88	4	2	2	2
2.2.1.1	D	a23	5	5	5	3
2.2.1.1	D	a28	6	13	23	36
...						
1.1.3	D	c16	625	625	625	623
4.1.1 A	D	f32	626	618	614	612
1.1.1 A	D	c2	627	627	627	627
7.5.1.2.1	D	f65	628	503	540	574
2.2.2.1.2	D	c35	629	629	629	629

Sample of ORDER-SA.WK1 spreadsheet Format
Table 14.

	A	B	C	D	E	F	G	H
1	ITEM	NO	PROP	TASK		CON	D/E	ID
2	292	100	CCCA	5.1.2.3		CON 510	D	a100
3	131	60	CCL	5.1.2.3		CON 510	D	e60
4	438	55	CCCA	5.1.2.3		CON 510	D	b55
5	523	56	CCCA	5.1.2.3		CON 510	D	c56
6	203	1	CCCA	5.1.2.3		CON 510	D	a1
7	41	39	CCH	5.1.2.3		CON 510	D	d39
8	545	80	CCCA	5.1.2.3		CON 510	D	c80
9	294	102	CCCA	5.1.2.3		CON 510	D	a102
10	477	5	CCCA	5.1.2.3		CON 510	D	c5
11	553	88	CCCA	5.1.2.3		CON 510	D	c88
12	303	110	CCCA	5.1.2.3		CON 510	D	a110
13								
14	15	14	CCH	1.2.1.2		CON 119	D	d14
15	404	15	CCCA	1.2.1.2		CON 119	D	b15
16	17	16	CCH	1.2.1.2		CON 119	D	d16
17	86	14	CCL	1.2.1.2		CON 119	D	e14
18	488	17	CCCA	1.2.1.2		CON 119	D	c17
19	12	12	CCH	1.2.1.2		CON 119	D	d12
20	16	15	CCH	1.2.1.2		CON 119	D	d15
21	90	18	CCL	1.2.1.2		CON 119	D	e18

I	J	K	L
CVk	AVG CVk	SUMMED CVk	OVERALL CVk
0.0002415372	0.0001998395	0.0021982344	0.0011990369
0.0000754046			
0.0001334280			
0.0001350191			
0.0003195901			
0.0001608628			
0.0001604136			
0.0002897614			
0.0002106754			
0.0001737289			
0.0002978134			
0.0002199633	0.0001543626	0.0012349011	0.0006946319
0.0000965490			
0.0002246941			
0.0000000000			
0.0001181743			
0.0002107043			
0.0002199504			
0.0001448657			

Sample of CONS.WK1 spreadsheet Format
Table 15.

The last spreadsheet file required to produce the final analytically ordered issue list was the CONS.WK1 spreadsheet file. This file calculated a consolidated capability value for the capability issues that resulted from the merging of similar issues submitted by the three study teams to eliminate redundancy in the list of issues. A sample of this spreadsheet file is shown in Table 15.

The next section deals with the macros written to build all the spreadsheet files illustrated in this portion of the paper. The requirement for format consistency becomes obvious when the work done by the macros is taken into consideration. Without the standardization of spreadsheet format throughout, movement between areas and location of data areas would have been impossible without extensive operator interface, which would have increased the duration of the project tenfold. Since the time available to complete the project was limited, operator involvement had to be minimized. Format consistency in spreadsheets coupled with extensive macros was the vehicle to achieve these results.

D. Macro Development

A powerful tool of Lotus 1-2-3 is the ability to perform many repetitious keystrokes rapidly by writing spreadsheet programs called macros. Without this powerful tool, the magnitude of data requiring processing would have made it impossible to use the multiple attribute decision tree technique. Some macros ran for seven hours to complete the operations required to build a single file. The remainder of this section will detail the macros used to manipulate the data, build the required files, calculate values, and develop the ordered list of issues for presentation to the Close Combat Capability Analysis General Officer Steering Committee (CCCA GOSC).

As previously stated, the first file developed was the raw data file containing all of the input provided by the CCCA, CCH, and CCL study teams. The first macros were written to facilitate the entry of data into this file. The differences in number of tasks and battlefield requirements input by the study teams made it necessary to have a number of slightly modified macros to complete the data entry process. All the macros were stored in a file called MACROS.WK1.

The first macro used to enter the task importance values and degradation/enhancement values was based on the nine battlefield requirements numbered BRa1 through BRa9. It allowed the operator

to use the numeric key pad to enter the values, while the macro moved the cursor throughout the matrix setup to receive the values. The macro was named \E and once the cursor was placed in the cell in the first column headed by BRa1, it could be invoked by pressing the ALT and E keys together (ALT-E).

Macro 1a: Entry of task and/or degradation/enhancement values in the RDATA.WK1 spreadsheet file for the BRa1 to BRa9 battlefield requirements.

	Name	Command	Explanation
	O	P	
1	\E	{?}	Pause for value to be entered.
2		{right}	Moves to next cell to receive data.
3		{?}	Pause for value to be entered.
4		{right}	Moves to next cell to receive data.
5		{?}	Pause for value to be entered.
6		{right}	Moves to next cell to receive data.
7		{?}	Pause for value to be entered.
8		{right}	Moves to next cell to receive data.
9		{?}	Pause for value to be entered.
10		{right}	Moves to next cell to receive data.
11		{?}	Pause for value to be entered.
12		{right}	Moves to next cell to receive data.
13		{?}	Pause for value to be entered.
14		{right}	Moves to next cell to receive data.
15		{?}	Pause for value to be entered.
16		{right}	Moves to next cell to receive data.
17		{?}	Pauses for last data entry in row.

Note: The operator enters a number and presses ENTER. If no data entry is necessary the operator presses ENTER to move to the next cell where an entry is required.

18	{down}	Moves down to the next row.
19	{left 8}	Moves to the first cell in row.
20	{branch P1}	Calls for the entry process to be repeated.

Note: The macro can be terminated at any point by pressing the

CTRL and Break keys together followed by the ESC key. To resume the macro, the cursor must be positioned in the first column (any row) of the matrix before pressing ALT-E.

By making minor modifications to macro 1, macros were generated to enter the data for battlefield requirements BRb1 through BRb8, BRc1 through BRc10, and BRd1 through BRg5.

Macro 1b: Entry of task and/or degradation/enhancement values in the RDATA.WK1 spreadsheet file for the BRb1 to BRb8 battlefield requirements.

Name	Command	Explanation
\E	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pauses for last data entry in row.
	{down}	Moves down to the next row.
	{left 7}	Moves to the first cell in row.
	{branch P1}	Calls for the entry process to be repeated.

Macro 1c: Entry of task and/or degradation/enhancement values in the RDATA.WK1 spreadsheet file for the BRc1 to BRc10 battlefield requirements.

Name	Command	Explanation
\E	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pauses for last data entry in row.
	{down}	Moves down to the next row.
	{left 9}	Moves to the first cell in row.
	{branch P1}	Calls for the entry process to be repeated.

Macro 1d: Entry of task and/or degradation/enhancement values in the RDATA.WK1 spreadsheet file for the BRd1 to BRd5, BRe1 to BRe5, BRf1 to BRf5, and BRg1 to BRg5 battlefield requirements.

Name	Command	Explanation
\E	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pause for value to be entered.
	{right}	Moves to next cell to receive data.
	{?}	Pauses for last data entry in row.
	{down}	Moves down to the next row.
	{left 4}	Moves to the first cell in row.
	{branch P1}	Calls for the entry process to be repeated.

The values for the theater/echelon/threat combinations and battlefield requirements were input by hand because the number of

entries to be made were comparatively small. However, this could have been accomplished by writing a simple macro similar to the ones outlined above.

The macro developed to build the TET#.WK1 spreadsheet files, # from 1 to 7, was more complicated because the work it had to accomplish was more involved. This macro was designed to fit all seven situations and would build the seven TET#.WK1 spreadsheet files without the need for time consuming debugging of the modified macros. The run time for this macro averaged approximately 2 hours, which is measurably less time than it would have taken to do all the entries by hand. The macro extracts the data from the raw data file related to the particular TEi (i from 1 to 7) under consideration, sorts it by battlefield requirement, and fills in all identifying characteristics of the decision tree branch.

Macro 2. Alignment of task importance values into identified multiple attribute decision tree branches. The resulting spreadsheet file named TET#.WK1 (# from 1 to 7) contains the data in the format required to follow attribute relationships and to complete future computations.

	Name	Command	Explanation
	O	P	
1	\B	/fccnBR{?}~RDATA~	Brings in the raw data.

Note: Macro pauses for operator to input specific range identifiers, e.g., a1, b1, etc.

	Name	Command	Explanation
	O	P	
2		/wcs13~	Sets column width to 13.
3		/wgc5~	Sets other column widths to 5.
4		{goto}AA210~	Positions cursor.
5		/cAA1.AK1~~	Copies headings from data matrix.
6		{down}{right}	Positions cursor.
7		+AB2>1#and#+AB2<>$X$2~	Enters selection criteria.
8		{goto}X10~	Positions cursor.
9		/rtAB1.AK1~~	Copies BR headings.
10		{end}{down}{down}	Positions cursor.
11		LAST~	Enters macro stopper.
12		{home}	Positions cursor.
13		^TEi	Enters heading.
14		{right}	Positions cursor.
15		^BRj	Enters heading.
16		{right}	Positions cursor.
17		/wcs13~	Sets column width to 13.
18		/cAA1~~	Enters heading.
19		{right}	Positions cursor.
20		/wcs15~	Sets column width to 15.
21		/cX10~~	Enters heading.
22		{goto}C1~	Positions cursor.
23		/dqr	Resets data query
24		iAA1.AK200~	Sets input range.
25		cAA210.AK211~	Sets criteria range.
26		o.{right}{pgdn 10}~	Sets output range.
27		eq	Extracts data and quits.
28		{right}	Positions cursor.
29		^TASK IMP	Enters heading.
30		{home}{down}	Positions cursor.
31		TE{?}~	Enters heading.

Note: Macro pauses for the operator to identify the value of i.

32		{right}	Positions cursor.
33		/cX10~~	Enters BR identity.
34		{left}	Positions cursor.
35		/c.{right}~	Copies the TEi and BRj identities
36		{down}.{right 2}	to data items extracted.
37		{end}{down}{left}~	
38		/fsTET{?}~	Saves spreadsheet file.

Note: Macro pauses for the operator to identify which theater/echelon/threat combination is being considered, that is, the value of i.

39	CTD	{goto}X11~	Positions cursor.
40		/m{end}{down}~{up}~	Brings new BR value into play.

	Name	Command	Explanation
	O	P	
41		{if $X$10="LAST"}{branch FIN}	Checks to see if BR list is exhausted.
42		{goto}AA210~	Positions cursor.
43		{down}{end}{right}	Positions cursor.
44		/c~{right}~	Enters new criteria.
45		/re~	Erases old criteria.
46		{goto}C1~	Positions cursor.
47		{end}{down}{down}	Positions cursor.
48		/cC1~~{right}/cX10~~	Enters headings.
49		{left}	Positions cursor.
50		/dqr	Resets data query ranges.
51		iAA1.AK200~	Sets input range.
52		cAA210.AK211~	Sets criteria range.
53		o.{right}{pgdn 10}~	Sets output range.
54		eq	Extracts data and quits.
55		{down}	Positions cursor.
56		/m{end}{down}	Moves extracted values into correct
57		{right}~{up}~	position.
58		{left}{up}	Positions cursor.
59		/cX10~~	Enters BRj designation.
60		{left}	Positions cursor.
61		/cA2~~	Enters TEi designation.
62		/c{right}~	Fills in TEi and BRj columns for
63		{down}.{right 2}	this group of data.
64		{end}{down}{left}~	
65		{branch CTD}	Re-enters macro at assigned point.
66	FIN	{home}	Positions cursor.
67		/fxvTI-{?}~	Forms TI-#.WK1 spreadsheet file.

Note: Macro pauses for operator to enter value of i.

68		{end}{down}	Highlights area to be extracted to
69		{right 3}~	the TI-#.WK1 spreadsheet file.
70		/fs~r	Saves completed spreadsheet file.

To build the TET#.WK1 spreadsheet file, on a blank spreadsheet screen position the cursor at the O1 cell, copy to this blank spreadsheet the range named TET from the MACROS.WK1 spreadsheet file. Move the cursor to P1 and name the range \B at P1 (Command: /rnc\B~~). Position the cursor at AA1 and invoke the macro by pressing the ALT and B keys (ALT-B) together.

The basis for building the TI-#.WK1 spreadsheet file was formed during the execution of Macro 2. In order to complete the building of the TI-#.WK1 spreadsheet files the TI macro would be brought into the TI-#.WK1 spreadsheet at the O1 cell from the MACROS.WK1 file. For example, the TI-1.WK1 spreadsheet would be retrieved and the cursor moved to the O1 cell, the following command would be given /fccnTI~MACROS~, and then the range containing the macro would be named by /rnc\B~P1~.

Macro 3: Translates the raw task importance values into the format useful to the multiple attribute decision tree technique.

	Name	Command	Explanation
	O	P	
1	\B	{goto}D2~	Positions cursor.
2		{edit}	Enters edit mode.
3		/8790	Enters operator and denominator.
4		{down}	Positions cursor.
5		/c~X1~	Enters value in checkpoint.
6		{if $X$1=$X$2}{home}/fs~r{quit}	Checks for another value and if none, saves file and quits.
7		{branch P2}	Continues execution.

When this macro has finished translating all task importance values, the operator must reset all range names, erase all extraneous information, and save the file. The main spreadsheet files, the TVK#.WK1 spreadsheet files, for the task evaluation portion of the analytical technique can be built once the seven TI-#.WK1 spreadsheet files are completed.

The TVK#.WK1 spreadsheet files were built using three separate macros called START (\S), INITIALIZE (\I), and PROGRAM (\A). Building the spreadsheet files begins by locating the cursor in cell A1, bringing in the range MACRO-4 from the MACROS.WK1 file, and naming the macro \S at range B2. These macros are invoked by pressing ALT-S, ALT-I, and ALT-A, respectively.

Macro 4 (START): Prepares the spreadsheet by setting column widths, formatting ranges for numerical values, bringing in data and headings, and naming macro ranges. Command: ALT-S.

	Name	Command	Explanation
	A	B	
1	START		Start up macro run initially.
2	\S	{goto}A1~/wcs5~	Sets column width.
3		{goto}B1~/wcs15~	Sets column width.
4		{goto}D1~/wcs5~	Sets TEi column width.
5		{goto}F1~/wcs13~	Sets TASK column width.
6		{goto}E1~/wcs7~	Sets empty column width.
7		{goto}G1~/wcs15~	Sets TASK IMP column width.
8		/rff10~G1.G700~	Sets 10 decimal digits format.
9		{goto}H1~/wcs15~	Sets TVk column width.
10		/rff10~H1.H700~	Sets 10 decimal digits format.
11		{goto}J1~/wcs7~	Sets BRj column width.
12		{goto}K1~/wcs15~	Sets FORMULAS column width.
13		/rnc\I~B50~	Names macro \i range.
14		/rnc\A~B22~	Names macro \a range.
15		/rncBRFIX~B33~	Names BRFIX subroutine range.
16		{goto}D1~	Positions cursor.
17		/fccnSETUP~MAC-1~	Calls SETUP from MAC-1.WK1 file.
18		{goto}D3~	Positions cursor.
19		/fcceTI-{?}~	Brings in TI-#.WK1 file.

Note: Macro pauses for operator entry of proper file number between 1 and 7.

Macro 4 (INITIALIZE): Continues to prepare spreadsheet for the calculation macro (PROGRAM) by bringing in proper formulas,

setting up checkpoint values, entering stop indicators, and creating initial save file. Command: ALT-I

	Name A	Name B	Command	Explanation
49	INITIALIZE			Initial macro run after START.
50	\I		{goto}K1~/wcs15~	Same as step 1.
51			FORMULAS~	Enters heading.
52			{goto}K3~	Positions cursor.
53			/fcenFORM{?}~MAC-1~	Brings in formulas to be used from MAC-1.WK1 file.

Note: Macro pauses for operator to enter number from 1 to 7 indicating the proper set of formulas to enter.

54			/cK3~B25~	Enters new formula.
55			/reK3~	Erases entry.
56			/cE2~J11~	Enters BRj output heading.
57			/cE2~J8~	Enters BRj criteria heading.
58			{goto}J9~*~	Positions cursor, enters *.
59			/dqr	Resets data query ranges.
60			iE2.E700~	Sets input range.
61			cJ8.J9~	Sets criteria range.
62			oJ11.J25~	Sets output range.
63			uq	Extracts unique BR and quits.
64			/mJ11~J10~	Moves heading up a cell.
65			/cJ12~J1~	Copies entry to checkpoint.
66			/cJ13~J2~	Copies entry to checkpoint.
67			/reJ12.J13~	Erases entries.
68			{goto}J14~	Positions cursor.
69			{end}{down}{down}	Positions cursor.
70			END~	Enters stop indicator.
71			{goto}E2~	Positions cursor.
72			{end}{down}{down}	Positions cursor.
73			LAST~	Enters stop indicator.
74			{goto}H3~	Positions cursor for next macro.
75			/fsTVK-{?}~	Saves file.

Note: Macro pauses for operator to entry a number between 1 and 7 corresponding to the TEi being considered.

Macro 4 (PROGRAM): Calculates the TVk for each entry. Command: ALT-A.

	Name	Command	Explanation
	A	B	
20	PROGRAM		Main macro run after INITIALIZE.
21			
22	\A	{left}/c~{right}~	Copies TI value for calculation.
23		{right}	Positions cursor.
24		{edit}{home}	Enters edit mode, places cursor.
25		90/335*50/660*	Enters formula for calculation.
26		{down}	Positions cursor.
27		{left 3}	Positions cursor.
28		/c~J1~	Enters next BR name in list.
29		{right 3}	Positions cursor.
30		{if J1="LAST"}/fs~r{quit}	Tests if LAST item calculated, yes then save file and quit macro.
31		{if J1=J2}{BRFIX}	Tests if BR changed, yes branch to BRFIX subroutine.
32		{branch B22}	Repeats macro \a.
33	BRFIX	{beep}/fs~r	Beeps upon entering subroutine and saves file.
34		{goto}K1~	Positions cursor.
35		{end}{down}	Positions cursor.
36		/c~B25~	Enters new formula.
37		/re~	Erases the formula cell.
38		{goto}J10~	Positions cursor.
39		{end}{down}	Positions cursor.
40		/c~J2~/re~	Enters current BR to check cell and erases cell.
41		{goto}H2~	Positions cursor.
42		{end}{down}	Positions cursor.
43		{down}	Positions cursor.
44		{left 3}/c~J3~	Enters next BR.
45		{right 3}	Positions cursor.
46		{if J3="LAST"}/fs~r{quit}	Checks if LAST, yes saves file and quits macro.
47		{return}	Returns to main macro routine.

Following the termination of the PROGRAM macro, the operator resets the range names, deletes columns A and B which contain the macros, deletes the column headed TASK IMP, erases any remaining items from columns J and K, names ranges of data to be extracted later, and saves the file. This provides a TVK#.WK1 spreadsheet file in the proper form for use in building the CVK#.WK1

spreadsheet files. Minor differences exist in the macros discussed above and those written to build the spreadsheet files from the Part II data inputs, that is, the degradation/enhancement spreadsheet files DET#.WK1, DE-#.WK1, and DEK#.WK1. These macros will not be discussed in the same detail as the previous ones.

Macro 5 (BUILD): Builds the DET#.WK1 spreadsheet files. It is invoked following the completion of macro \I. Command: ALT-B.

	Name	Command	
	V	W	
1	BUILD		
2	\B	{goto}N1~	Locate TEi output column.
3		{end}{down}	Locate end of column.
4		{down}	Locate empty cell.
5		{right 2}	Locate output area.
6		/cP1.S1~~	Enters headings.
7		{end}{right}	Locate DE value column.
8		/cAA1~~	Enter specific BRj heading.
9		{goto}A204~	Locate criterion area.
10		{right}	Locate previous criteria
11		{end}{right}	value.
12		/c~{right}~	Enter next criteria value.
13		/re~	Remove previous criteria value.
14		{goto}P1~	Locate output column.
15		{end}{down}	Locate output area.
16		/dqr	Reset data query ranges.
17		iA2.M201~	Set input range.
18		cA203.M204~	Set criteria range.
19		o.{end}{right}	Set output range.
20		{pgdn 10}~	
21		eq	Extracts data and quits.
22		/fs~r	Saves file.
23		{right 3}	Locate specific BRj.
24		/c~{left 4}~	Enter specific BRj in BRj column.
25		{left 3}	Locates current TEi column.
26		/re{end}{right}~	Erases headings.
27		{down}	Locates data.
28		/m{end}{right}	Moves data up one cell.
29		{end}{down}~	
30		{up}~	
31		{up}	Positions cursor.
32		{left 2}	
33		{up}	

	Name	Command	
	V	W	
34		/c~{down}~	Enters specific TEi.
35		{down}	Positions cursor.
36		/c{right}~	Completes TEi and BRj columns
37		{down}.{right 2}	for extracted data.
38		{end}{down}{left}~	
39		{goto}Z1~	Positions cursor.
40		{end}{down}	Locates next BRj.
41		/c~AA1~/re~	Enters in check point.
42		{if AA1=$B$1}/fs~r{goto}N1~{quit}	Checks for stop.
43		{branch W2}	If not continues macro.

Macro 5 (INITIAL): Prepares the spreadsheet, imports the required data from the RDATA.WK1 spreadsheet file, and extracts the first data set. Command: ALT-I.

	Name	Command	
	V	W	
47	INITIAL		
48	\I	{goto}Z1~	Positions cursor.
49		BRj~	Enters heading.
50		{down 2}	Positions cursor.
51		/cD2~~	Enters specific BRj values
52		{down}	under consideration.
53		/cE2~~	
54		{down}	
55		/cF2~~	
56		{down}	
57		/cG2~~	
58		{down}	
59		/cH2~~	
60		{down}	
61		/cI2~~	
62		{down}	
63		/cJ2~~	
64		{down}	
65		/cK2~~	
66		{down}	
67		/cL2~~	
68		{down}/cM2~~	
69		{goto}Z1~	Positions cursor.
70		{end}{down}	Locates check value.
71		/c~AA1~	Enters check point.
72		/re~	Erase value.
73		/rnc\B~W2~	Names macro \B.

	Name	Command	
	V	W	
74		/rnc\F~W115~	Names macro \F.
75		{goto}N1~/wcs5~	Set TEi output column width.
76		/fccnSETUP2~MAC-1~	Enter headings.
Note: Macro pauses for operator to enter value of i.			
77		{goto}O1~/wcs7~	Set BRj column width.
78		{goto}P1~/wcs5~	Set D/E column width.
79		{goto}Q1~/wcs5~	Set ID column width.
80		{goto}R1~/wcs13~	Set TASK column width.
81		{goto}S1~/wcs9~	Set D/E value column width.
82		{goto}A203~	Locate criteria area.
83		/cA2.M2~~	Enter headings.
84		{down}{right}	Position cursor.
85		*~	Enter criteria.
86		{right 2}	Position cursor.
87		+D3>0#and#D3<>$B$1~	Enter criteria.
88		{goto}N1~	Locate TEi column.
89		{goto}S1~	Locate D/E value column.
90		/cAA1~~	Enter specific BRj.
91		/dqr	Reset data query ranges.
92		iA2.M201~	Set input range.
93		cA203.M204~	Set criteria range.
94		oP1.S200~	Set output range.
95		eq	Extract data and quit.
96		/fsDET{?}~	Save file.
Note: Macro pauses for the operator to enter a value from 1 to 7.			
97		D/E VALUE~	Enter heading.
98		{goto}N1~	Position cursor.
99		{down}	
100		TE{?}~	Enter specific TEi.
Note: Macro pauses for operator to enter the value of i.			
101		{right}	Position cursor.
102		/cAA1~~	Enter specific BRj.
103		{left}	Position cursor.
104		/c{right}~	Enter specific TEi and BRj
105		{down}.{right 2}	for extracted data.
106		{end}{down}{left}~	
107		{goto}Z1~	Locate BRj list.
108		{end}{down}	Locate next BRj.
109		/c~AA1~	Enter check point.
110		/re~	Erase value.
111		{goto}N1~	Locate TEi column.
112		/fs~r	Save file.

Macro 5 (FINISH): Builds the DE-#.WK1 spreadsheet file by extracting the necessary data and saves the completed DET#.WK1 spreadsheet file. Command: ALT-F.

	Name	Command	Explanation
	V	W	
116	FINISH		
115	\F	{goto}N1~	Locates extraction data.
116		/fxvDE-{?}~	Builds DE-#.WK1 file.

Note: Macro pauses for operator to enter the appropriate value from 1 to 7.

117		{end}{right}	Indicates extraction range.
118		{end}{down}~	
119		{home}	Locates beginning of file.
120		/fs~r	Saves file.

Macro 6 (START): Prepares the spreadsheet, imports the required data, names the macros, and saves the file. Command: ALT-S.

	Name	Command	
	O	P	
1	START		
2	\S	{goto}A1~/wcs5~	Sets TEi column width.
3		{goto}B1~/wcs7~	Sets BRj column width.
4		{goto}D1~/wcs5~	Sets ID column width.
5		{goto}E1~/wcs13~	Sets TASK column width.
6		{goto}F1~/wcs15~	Sets D/E value column width.
7		/rff10~F2.F1000~	Setting 10 decimal format.
8		{goto}G1~/wcs15~	Sets DEk column width.
9		/rff10~G2.G1000~	Setting 10 decimal format.
10		{goto}C1~/wcs5~	Set D/E column width.
11		{goto}J1~/wcs7~	Set BRj list column width.
12		{goto}K1~/wcs15~	Set Formula list column width.
13		/rnc\I~P50~/rnc\F~P85~	Names macros \I and \F.
14		/rnc\A~P22~	Names macro \A.
15		/rncBRFIX~P33~	Names BRFIX range.
16		{goto}G1~	Locates DEk column.
17		DEk~{goto}A1~	Enters heading; positions cursor.
18		/fcceDE-{?}~	Imports DE-# file.
19		/fsDEK{?}~	Saves file.

Macro 6 (PROGRAM): Calculates the DEk values. Command: ALT-A.

	Name	Command	
	O	P	
21	PROGRAM		
22	\A	{left}/c~{right}~	Positions cursor; copies D/E val.
23		{right}	Positions cursor.
24		{edit}{home}	Enters edit mode.
25		60/335*20/515*	Sets formula for DEk calculation.
26		{down}	Positions cursor.
27		{left 5}	
28		/c~J1~	Enter BRj in check point.
29		{right 5}	Position cursor.
30		{if J1="LAST"}/fs~r{quit}	Check LAST and quit.
31		{if J1=J2}{BRFIX}	If same, call subroutine.
32		{branch P22}	Otherwise, repeat macro.
33	BRFIX	{beep}/fs~r	Save file.
34		{goto}K1~	Locate formuls list.
35		{end}{down}	Locate next formula.
36		/c~P25~	Enter in macro.
37		/re~	Erase used value.
38		{goto}J10~	Locate BRj list.
39		{end}{down}	Locate next BRj.
40		/c~J2~/re~	Enter in check point and erase.
41		{goto}G2~	Locate DEk column.
42		{end}{down}	Locate last entry.
43		{down}	Locate next empty cell.
44		{left 5}/c~J3~	Enter BRj to check point.
45		{right 5}	Locate DEk column position.
46		{if J3="LAST"}/fs~r{quit}	If LAST quit.
47		{return}	Return to macro step 32.

Macro 6 (INITIAL): Completes the preparation of the spreadsheet file by entering check point values, importing computational formulas from MACROS.WK1, and extracting initial data set. Command: ALT-I.

	Name	Command	
	O	P	
49	INITIAL		
50	\I	{goto}K1~/wcs15~	Locate formula column.
51		FORMULAS~	Enter heading.
52		{goto}K3~	Position cursor.
53		/fccnFORM{?}~MACROS~	Import formulas.
54		/cK3~P25~	Enter formula in macro.
55		/reK3~	Erase used value.
56		/cB1~J11~	Enter heading.

	Name	Command	
	O	P	
57		/cB1~J8~	Enter heading.
58		{goto}J9~*~	Enter criteria.
59		/dqr	Reset data query ranges.
60		iB1.B1000~	Set input range.
61		cJ8.J9~	Set criteria range.
62		oJ11.J25~	Set output range.
63		uq	Extract unique data.
64		/mJ11~J10~	Move heading.
65		/cJ12~J1~	Copy 1st BRj to check point.
66		/cJ13~J2~	Copy 2nd BRj to check point.
67		/reJ12.J13~	Erase both values.
68		{goto}J14~	Position cursor.
69		{end}{down}{down}	Locate end of list.
70		END~	Enter stop indicator.
71		{goto}B1~	Locate BRj column.
72		{end}{down}{down}	Locate end of list.
73		LAST~	Enter stop indicator.
74		{goto}F2~	Locate 1st D/E value.
75		/rnc\T~P78~	Name macro \T.

Macro 6 (TRANS): Calculates the translated degradation/enhancement value. Command: ALT-T.

	Name	Command	
	O	P	
77	TRANS		
78	\T	{edit}/8810~	Calculate translated value.
79		{down}	Locate next entry.
80		{branch P78}	Repeat macro.

The next macro to be discussed in its entirety is the macro written to build the capability value (CVK#-##.WK1) spreadsheet files.

Macro 7. In a series of linked macros, imports the raw data; aligns unique tree branch paths; calculates individual CVk.

The macro \S is the set up macro for the CVK#-##.WK1 spreadsheet file. It prepares the spreadsheet by setting column widths, importing the TVK#.WK1 and DEK#.WK1 spreadsheet files, and sorting the data by tasks. Command: ALT-S.

	Name	Command	Explanation
	V	W	
1	\S	{goto}A1~/wcs5~	Sets TEi column width.
2		{goto}B1~/wcs7~	Sets BRj column width.
3		{goto}C1~/wcs13~	Sets TASK column width.
4		{goto}D1~/wcs15~	Sets TVk column width.
5		{goto}F1~/wcs5~	Sets TEi column width.
6		{goto}G1~/wcs7~	Sets BRj column width.
7		{goto}H1~/wcs4~	Sets D/E column width.
8		{goto}I1~/wcs5~	Sets ID column width.
9		{goto}J1~/wcs13~	Sets TASK column width.
10		{goto}K1~/wcs15~	Sets DEk column width.
11		{goto}A1~	Positions cursor.
12		/fcceTVK{?}~	Imports TVK#.WK1 file data.

Note: Macro pauses for operator to input proper file indicator, that is, a number from 1 to 7.

13	{down}/m{right 3}{end}	Eliminates headings.
14	{down}~{up}~	
15	/dsr	Resets sort parameters.
16	d.{end}{right}	Enters data for sort.
17	{end}{down}~	
18	p{right 2}.{end}{down}~a~	Enters primary sort field.
19	s{right}.{end}{down}~a~g	Enters secondary sort field and sorts data.
20	{goto}F1~	Positions cursor.
21	/fcceDEK{?}~	Imports DEK#.WK1 file data.

Note: Macro pauses for operator to input proper file indicator, that is, a number from 1 to 7.

22	{down}/dsr	Positions cursor and resets sort parameters.
23	d.{end}{right}{end}{down}~	Enters data range for sort.
24	p{right 4}.{end}{down}~a~	Enters primary sort field.
25	s{right}.{end}{down}~a~g	Enters secondary sort field.

The macro \I continues to prepare the spreadsheet by creating output areas, check point areas, and aligning the first set of TVk and DEk values. Command: ALT-I.

	Name	Command	Explanation
	V	W	
1	\I	{goto}M1~/wcs5~/cA1~~	Sets TEi column width.
2		{goto}N1~/wcs7~/cB1~~	Sets BRj column width.
3		{goto}O1~/wcs13~/cC1~~	Sets TASK column width.
4		{goto}P1~/wcs15~/cD1~~	Sets TVk column width.
5		/rff10~P2.P500~	Sets 10 decimal places.
6		{goto}Q1~/wcs3~	Sets space column width.
7		{goto}R1~/wcs5~/cH1~~	Sets D/E column width.
8		{goto}S1~/wcs6~/cI1~~	Sets ID column width.
9		{goto}T1~/wcs15~/cK1~~	Sets DEk column width.
10		/rff10~T2.T500~	Sets 10 decimal places.
11		{goto}A360~/cA1.D1~~	Enters criteria headings.
12		{goto}F510~/cF1.K1~~	Enters criteria headings.
13		{goto}J511~*~	Enters criteria.
14		{goto}V1~/wcs4~	Enters macro name column width.
15		{goto}W1~/wcs25~	Enters macro command column width.
16		{goto}Z2~/wcs13~/cJ1~~	Prepares TASK output area.
17		/dqr	Resets data query values.
18		iJ1.J500~	Enters input range.
19		cJ510.J511~	Enters criteria range.
20		oZ2.Z100~	Enters output range.
21		uq	Extracts unique data values.
22		{end}{down}	Positions cursor.
23		{down}LAST~	Enters stop point.
24		/mZ2~Z1~	Moves heading.
25		{goto}Y2~/wcs7~/cG1~~	Prepares BR output area.
26		/cJ511~B361~	Enters criteria.
27		/dqr	Resets data query values.
28		iB1.B350~	Enters input range.
29		cB360.B361~	Enters criteria range.
30		oY2.Y20~	Enters output range.
31		uq	Extracts unique data values.
32		{end}{down}	Positions cursor.
33		{down}LAST~	Enters stop point.
34		/mY2~Y1~	Moves heading.
35		{goto}Y3~	Positions cursor.
36		/dsr	Resets data sort values.
37		d.{end}{down}{up}~	Enters data range to sort.
38		p.{end}{down}{up}~a~g	Enters primary sort range and sorts data.
39		{goto}Z1~	Positions cursor.
40		{end}{down}	Locates value.

	Name	Command	Explanation
	V	W	
41		/c~C361~/c~J511~/re~	Enters criteria and erases cell.
42		{goto}Y1~{end}{down}	Locates value.
43		/c~B361~/c~G511~/re~	Enters criteria and erases cell.
44		{goto}AA1~/cA2~~	Enters check values.
45		{down}D~{down}E~	Enters check values.
46		{down 2}\--~	Enters check values.

The next series of small macros linked by logical if-then statements comprise the main program completing the alignment of the TVk and DEk values to facilitate the computation of the CVk values. Macro \A completes the initial alignment of the two values and sets the range for macro \M, the macro that sets the ranges for all the remaining macros in the chain.

	Name	Command	Explanation
	V	W	
1	\A	{goto}M1~	Positions cursor.
2		/dqr	Resets data query ranges.
3		iA1.D350~	Enters input range.
4		cA360.D361~	Enters criteria range.
5		oM1.P50~	Enters output range.
6		eq	Extracts data; quits query.
7		/dqr	Resets data query ranges.
8		iF1.K500~	Enters input range.
9		cF510.K511~	Enters criteria range.
10		oR1.T50~	Enters output range.
11		eq/rnc\m~W105~	Extracts data; quits query; names macro \M range.

Macro \B is the main program macro for the build of this spreadsheet file. It extracts and aligns TVk and DEk values with the proper identifiers through logical links with macros \C, \D, \E, \F, \G, \H, \J, and \K. It is invoked by the command ALT-B, and as required during execution invokes the other macros. This form of macro allows the operator to stop the macro at certain points, and restart by invoking one of the sub-macro routines.

	Name	Command	Explanation
	V	W	
13	\B	{goto}Y1~{end}{down}	Positions cursor.
14		/c~B361~/c~G511~/re~	Enters criteria, erases cell.
15		{goto}M1~	Locates output column.
16		{if B361="LAST"}{beep}{branch W53}	Checks stop, if yes call \D.
17		{end}{down}{down}	If no, locates output area.
18		/cM1.T1~~	Enters headings.
19		/dqr	Resets data query ranges.
20		iA1.D350~	Enters input range.
21		cA360.D361~	Enters criteria range.
22		o.{right 3}{pgdn}~	Enters output range.
23		eq	Extracts data; quits query.
24		{right 5}	Locates second output area.
25		/dqr	Resets data query ranges.
26		iF1.K500~	Enters input range.
27		cF510.K511~	Enters criteria range.
28		o.{right 2}{pgdn}~	Enters output range.
29		eq	Extracts data; quits query.
30		{left 5}/reX1.X3~	Positions cursor, erases check point cells.
31		{down}/c~X1~	Enters value for check.
32		{right 5}/c~X2~	Enters value for check.
33		{down}/c~X3~	Enters value for check.
34		{up 2}{left 5}	Returns cursor to position.
35		{if $X$1=$AA$1}{branch W95}	Checks if \J to be called.
36		{if $X$1=$AA$4}{branch W99}	Checks if \K to be called.
37		{branch W13}	Continues \B.

Macro \C is called when it is necessary to fill in the information not provided in the Part I input, i.e., the valuation of a task. A zero entry is made for TVk in order to provide a criteria for identifying situations if re-entry of values is allowed later in the process.

	Name	Command	Explanation
	V	W	
41	\C	{down}/cA2~~	Enters proper TEi.
42		{right}/cB361~~	Enters proper BRj.
43		{right}/cC361~~	Enters proper TASK.
44		{right}0~	Enters TVk of 0.
45		{left 3}{up}	Positions cursor.

	Name	Command	Explanation
	V	W	
46		{if $X$3=$AA$2#or#$X$3=$AA$3}{branch W91}	More entries required then call \H.
47		{down}/m{right 7}~{up}~	Eliminate output headings.
48		{branch W13}	Continue \B.

Macro \D is invoked when it is necessary to rebuild the BRj list used to construct the criteria for data extracts. In addition if it finds the task list used to construct the criteria for data extracts has been exhausted, then \D will save the spreadsheet file and exit the macro.

	Name	Command	Explanation
	V	W	
53	\D	{goto}M1~{end}{down}{beep}	Positions cursor; signals.
54		{down}/cAA5~.{right 2}~/cAA5~{right 5}.{right}~/fs~r	Enters \----.
55		{goto}Z1~{end}{down}	Positions cursor.
56		/c~C361~/c~J511~/re~	Enters criteria; erases cell.
57		{if C361="LAST"}{beep 2}{quit}	Checks stop, yes then exit.
58		{goto}Y2~/cG1~~	Enters output heading.
59		/cG1~Y20~	Enters criteria heading.
60		{goto}Y21~*~{goto}Y2~	Enters criteria; positions cursor.
61		/dqr	Resets data query ranges.
62		iB1.B350~	Enters input range.
63		cY20.Y21~	Enters criteria range.
64		oY2.Y19~	Enters output range.
65		uq	Extracts unique data values.
66		{end}{down}	Positions cursor.
67		{down}LAST~	Enters stop value.
68		/mY2~Y1~	Moves heading.
69		{goto}Y3~	Positions cursor.
70		/dsr	Resets data sort ranges.
71		d.{end}{down}{up}~	Enters data sort range.
72		p.{end}{down}{up}~a~g	Enters primary sort range.
73		{branch W13}	Continues \B.

Macro \E is invoked under certain conditions by \J. It compares entries to checkpoints and either invokes \H or eliminates output headings and continues \B.

	Name	Command	Explanation
	V	W	
76	\E	{if $X$3=$AA$2#or#$X$3=$AA$3}{branch W91}	More than one line call \H.
77		{down}/m{right 7}~{up}~	Eliminate output headings.
78		{branch W13}	Continue \B.

Macro \F is called if no data is found during the extract operation. In the set up the particular data checks in this situation it is an unnecessary macro, however, under different conditions it would be a valuable addition to the program.

	Name	Command	Explanation
	V	W	
83	\F	/re{right 7}~	Eliminates output headings.
84		{branch W13}	Continues \B.

Macro \G is invoked by \J when no useful data is found during extract operations. It erases any TVk data that has been found without corresponding DEk data, and continues \B.

	Name	Command	Explanation
	V	W	
87	\G	/re{right 7}{end}{down}~	Erases extract range.
88		{branch W13}	Continues \B.

Macro \H is called by macros \C and \E to fill in data values when more than one DEk data set is aligned to a TVk value. It accomplishes this requirement and continues \B.

	Name	Command	Explanation
	V	W	
91	\H	{down}/c{right 3}~.{right 5}{end}{down}{left 2}~	Copies the single TVk data set to each of the extracted DEk data sets.
92		/m{right 7}{end}{down}~{up}~{branch W13}	Eliminates output headings and continues \B.

Macro \J is called by \B if data is successfully extracted. It determines the extent of the data and calls either \E or \G whichever is applicable.

	Name	Command	Explanation
	V	W	
95	\J	{if $X$2=$AA$2#or#$X$2=$AA$3}{branch W76}	DEk data exists call \E.
96		{branch W87}	Otherwise call \G.

Macro \K is called by \B if no TVk data is found after extract operations are complete. It checks for DEk data and calls \C or \F, as appropriate.

	Name	Command	Explanation
	V	W	
99	\K	{if $X$2=$AA$2#or#$X$2=$AA$3}{branch W41}	DEk data present call \C.
100		{branch W83}	Otherwise call \F.
101			

Macro \M is called by the operator after the compietion of \A to name all macros and their ranges.

	Name	Command	Explanation
	V	W	
105	\M	/rnc\B~W13~	Names macro and range.
106		/rnc\C~W41~	Names macro and range.
107		/rnc\D~W53~	Names macro and range.
108		/rnc\E~W76~	Names macro and range.
109		/rnc\F~W83~	Names macro and range.

	Name	Command	Explanation
	V	W	
110		/rnc\G~W87~	Names macro and range.
111		/rnc\H~W91~	Names macro and range.
112		/rnc\J~W95~	Names macro and range.
113		/rnc\K~W99~	Names macro and range.

To begin to build the desired CVK#-##.WK1 spreadsheet file, the operator must place the cursor in cell V1, import Macro 8 from the MACROS.WK1 file with the command '/fncMACRO7~MACROS~', name the macro \S at range W1 with the command /rnc\S~W1~, invoke the macro with the command ALT-S, and respond to requests for input of the desired values from 1 to 7 at the pauses.

Once the corresponding TVk and DEk values have been properly aligned, the operator is able to prepare the file for the calculation of the CVk values. The operator must reset all range names, erase the macros in the range V1 to W113, delete columns A through L, save the file, position the cursor in cell V1, import Macro 8 from MACROS.WK1, name the macro \S at range W1, and invoke the macro with the command ALT-S.

Macro 8: Corrects the setup of the spreadsheet, prepares the output areas, enters weighting factors, calculates CVK for each aligned TVK and DEK, computes average CVK for data grouped by ID, and prepares data for import into the CONS.WK1 spreadsheet file using four separate macros. These macros are SETUP (\S), Calculate (\C), INITIAL (\I), and AVERAGE (\A) in order of use.

Macro \S (SETUP) is invoked by the operator. It revises the spreadsheet format to suit the data remaining, enters required headings and weighting factors, prepares the output area for use by future macros, and names the remaining macros and their ranges. Command: ALT-S.

	Name	Command	Explanation
	V	W	
1	\S	{goto}A1~/wcs5~	Sets TEi column width.
2		{goto}B1~/wcs7~	Sets BRj column width.
3		{goto}C1~/wcs13~	Sets TASK column width.
4		{goto}D1~/wcs15~	Sets TVk column width.
5		{goto}E1~/wcs3~	Sets empty column width.
6		{goto}F1~/wcs4~	Sets D/E column width.
7		{goto}G1~/wcs6~	Sets ID column width.
8		{goto}H1~/wcs15~	Sets DEk column width.
9		{goto}I1~/wcs15~~CVk~	Sets CVk column width and enters heading.
10		/rff10~{left 2}{end}{down}	Sets 10 decimal place number
11		{right}~	range.
12		{goto}Y1~.4~	Enters TVk weighting factor.
13		{right}.6~	Enters DEk weighting factor.
14		{goto}J1~/wcs3~	Enters empty column width.
15		{goto}K1~/wcs5~/CA1~~	Prepares TEi output column.
16		{goto}L1~/wcs7~/CB1~~	Prepares BRj output column.
17		{goto}M1~/wcs13~/CC1~~	Prepares TASK output column.
18		{goto}N1~/wcs4~/CF1~~	Prepares D/E output column.
19		{goto}O1~/wcs6~/CG1~~	Prepares ID output column.
20		{goto}P1~/wcs15~/CI1~~	Prepares CVk output column.
21		{goto}I2~	Positions cursor for \C.
22		/rnc\C~W26~	Names macro \C range.
23		/rnc\I~W ~	Names macro \I range.
24		/rnc\A~W ~	Names macro \A range.

Macro \C (Calculate) calculates the CVk for each pair of TVk and DEk. Command: ALT C.

	Name	Command	Explanation
	V	W	
26	\C	{goto}I2~	Positions cursor.
27		+D2*$Y$1+H2*$Z$1~	Enters computation formula.
28		/c~.{left}{end}{down}{right}~	Enters computation formula for set of similar data.
29		{end}{down}{down 2}	Locates next data set.
30		/cI2~.{left}{end}{down}{right}~	Enters computation formula for data set.
31		{end}{down}{down 2}	Locates next data set.
32		{left}/c~AA1~{down}/c~AA3~{UP}{right}	Enters check points.
33		{if $AA$1=$AA$2}/fs~r{quit}	No data, save file, end macro.
34		{if $AA$3=$AA$2}{branch W36}	Single entry, continue at W36.
35		{branch W30}	Otherwise back to W30.
36		/cI2~~{down 2}	Enter computation formula
37		{branch W30}	Continue macro at W30.

Macro \I (INITIAL) prepares for the extraction of data sets by preparing check points and criteria values, and makes the first data extraction to the output area. Command: ALT-I.

	Name	Command	Explanation
	V	W	
39	\I	{goto}A1000~/cA1.I1~~	Prepares criteria area.
40		{goto}G1001~	Positions cursor.
41		{?}*~	Enters ID criteria.

Note: Macro pauses for operator to input the first letter of ID under consideration, i.e., a, b, c, d, e, f, or g.

42		{goto}AB2~	Locates output area.
43		/cG1~~	Enters ID output heading.
44		/dqr	Resets data query ranges.
45		iG1.G980~	Enters input range.
46		cG1000.G1001~	Enters criteria range.
47		oAB2.AB300~	Enters output range.
48		uq	Extracts unique ID values.
49		{end}{down}{down}	Locates end of list.
50		LAST~	Enters stop point.
51		{goto}AB1~	Positions cursor.
52		/mAB2~AB1~	Moves heading up.

	Name	Command	Explanation
	V	W	
53		{end}{down}	Locates beginning of list.
54		/dsr	Resets data sort ranges.
55		d.{end}{down}{UP}~	Enters data range for sort.
56		p.{end}{down}{UP}~A~G	Enters sort values and sorts.
57		/c~G1001~/re~	Enters criteria, erases entry.
58		{goto}K1~	Locates output area.
59		/dqr	Resets data query ranges.
60		iA1.I980~	Enters input range.
61		cA1000.I1001~	Enters criteria range.
62		oK1.Q25~	Enters output range.
63		eq	Extracts and exits query.

After the operator checks the results of macro \I, calculates the average CVk for the first set of data extracted, enters "\--" at the end of the data in column K, and saves the file; macro \A can be invoked to complete the building of the spreadsheet file.

Macro \A (AVERAGE) extracts data sets and calculates the average CVk for the set. Command: ALT-A.

	Name	Command	Explanation
	V	W	
65	\A	{goto}AB1~	Position cursor.
66		{end}{down}	Locates next criteria value.
67		/c~G1001~/RE~	Enters criteria value.
68		{if G1001="LAST"}/fs~r{quit}	Checks for stop point if present, saves file and exits macro.
69		{goto}K1~	Locates output area.
70		{end}{down}	Moves cursor to end of column.
71		{down}/cK1.Q1~~	Enters output headings.
72		/dqr	Resets data query ranges.
73		iA1.I980~	Enters input range.
74		cA1000.I1001~	Enters criteria range.
75		o.{right 5}{pgdn 2}~	Enters output range.
76		eq	Extracts and exits query.
77		/re{right 6}~\--~	Enters set separator.
78		{down}{right 5}	Positions cursor.
79		/rndAVG~	Clears old calculation range.
80		/rncAVG~{end}{down}~	Enters new calculation range.

	Name	Command	Explanation
	V	W	
81		{right}@avg(AVG)~	Calculates average CVk.
82		/rv~~	Translates formula to value.
83		{branch W65}	Continues \A.

When all the average CVk values have been calculated, the operator will clear all extraneous data from the spreadsheet and prepare an area for the extraction of the average CVk values and the ID values. The range occupied by this data will be named so that the data can be imported into the CONS.WK1 spreadsheet file when it is required.

The CONS.WK1 spreadsheet file had as its basis a spreadsheet file created by the Operations and Combat Developments (O/CD) team, who was charged with the responsibility of consolidating the capability issues identified by the three study teams (CCCA, CCH, and CCL). Much of the building of the CONS.WK1 spreadsheet file was accomplished by hand, the few macros that were utilized were simple and written on the spot as needed. The one macro that was retained is the macro 9 written to calculate the overall capability value (CVk) for each consolidated capability issue. It will be the final macro discussed in this paper.

Macro 9: Calculates the overall capability value for each consolidated capability issue.

	Name	Command	Explanation
	V	W	
1	\V	{goto}I2~	Positions cursor.
2		/rncCVK~	Names range of values.

	Name	Command	Explanation
	V	W	
3		{end}{down}~	Enters range to consider.
4		{right}@avg(CVK)~	Calculates average of CVk.
5		{right}@sum(CVK)~	Calculates sum of CVk.
6		{right}(@avg(CVK)+@sum(CVK))/2~	Calculates overall CVk.
7		{left}	Positions cursor.
8		/rv{right}~~	Changes formulas to values.
9		/rndCVK~	Clears calculation range name.
10		{left}{end}{down}{down 2}	Locates next data set.
11		/c~AA1~{down}/c~AA2~{up}	Enters check points.
12		{if $AA$1=$AA$3}/fs~r{quit}	Check for next value, if none, save file and exit macro.
13		{if $AA$2=$AA$3}/c~{right}.{right}	Check if single entry, if yes, copy for average and sum.
14		{branch W2}	Continue \V at W2.

After the macro has calculated all the overall capability values, the operator can extract the consolidated capability issues and the corresponding overall capability values, and produce an ordered capability issue list by sorting on the overall CVk in descending order.

I would like to conclude this discussion of macros with the observation that many improvements can be made to enhance the macros used to build the spreadsheet files, however, at the time the project was in progress, the luxury of finding the most efficient macro technique was not available. The job had to be done and the macros presented accomplished the task.

E. Computation.

When the data from the three Part I reports was tabulated, forty-one battlefield requirements had been identified and were distributed among seven theater/echelon/threat combinations. A total of 200 Blueprint of the Battlefield tasks had been selected as being essential, that is, "those tasks that must be accomplished to complete the overall mission" [20], and were associated with one or more of the battlefield requirements. The potential requirement for over three thousand individual calculations existed at the task valuation stage of the process. This number increased substantially with the tabulation of the data from the three Part II reports. All calculations were accomplished by utilizing macros with the LOTUS 1-2-3 spreadsheet software, as previously outlined in an earlier section. The algorithms employed were derived from the stated relationships of the attributes, and the axioms of Bayesian statistical decision theory. The following quote from an article by Dr. Martin in Publications in Operations Research No. 13 highlights those important to this particular application.

> The axioms and basic theorems of Bayesian decision theory have been stated in various forms, but essentially involve the following:

[20] U.S. Army Command and General Staff College Student Text 100-9, The Command Estimate (Fort Leavenworth, KS: CGSC, 1986). p. 3-4.

> 1. There exists a preference relation $\succ$ over the set of all consequences.
>
> 2. The decision maker can express his preference for consequences by a real-valued function ... .
>
> 3. The decision maker can express his judgments about the relative likelihood of the states of nature and the experimental outcomes by means of a probability function. [21]

Initial calculations were required to translate the raw valuations from the study teams into the format compatible with the decision tree technique. These were simple divisions by a value selected to suit the given situation. Two sets of algorithms were used to calculate the translated values for the raw data values. One for the theater/echelon/threat and battlefield requirement values, and a second for the task importance and degradation/enhancement values. These algorithms are as follows:

$$TEi = (RVi)/(RVi)$$

where TE is the theater/echelon/threat combination value, RV is the raw value assigned, and i is a number from 1 to 7 which indicates the theater/echelon/threat combination.

$$BRj = (RVj)/(RVj)$$

where BR is the battlefield requirement value, RV is the raw

[21] J. J. Martin, "Bayesian Decision Problems & Markov Chains," in Publications in Operations Research No. 13, ed. David B. Hertz (New York: John Wiley & Sons, Inc., 1967), p. 8.

value assigned, and j is an expression from a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5 which identifies the battlefield requirement.

$$TIk = (RVk)/max[\ (RVjk)]$$

where TI is the task importance value, RV is the raw value assigned, j is an expression from a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5 which identifies the battlefield requirement, and k is an expression that identifies the Blueprint of the Battlefield task, e.g., 4.1.1.1.

$$CIk = (RVk)/max[\ (RVjk)]$$

where CI is the capability issue value, RV is the raw value assigned, j is an expression from a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5 which identifies the battlefield requirement, and k is an expression that identifies the Blueprint of the Battlefield task, e.g., 4.1.1.1.

Illustrations of these algorithms are shown in the spreadsheet files accomplishing the computations, RDATA.WK1, TI-1.WK1, and DE-1.WK1, in Tables 16, 17, and 18 respectively.

	B	C	D	E
1	THEATER/ECHELON/THREAT COMBINATIONS			
2	TEi	TEi VALUE		TRANSLATED VALUE
3	TE1	90.0000		+C3/@SUM($C$4..$C$9)
4	TE2	70.0000		+C4/@SUM($C$4..$C$9)
5	TE3	60.0000		+C5/@SUM($C$4..$C$9)

6	TE4	40.0000	+C6/@SUM($C$4..$C$9)
7	TE5	30.0000	+C7/@SUM($C$4..$C$9)
8	TE6	25.0000	+C8/@SUM($C$4..$C$9)
9	TE7	20.0000	+C9/@SUM($C$4..$C$9)
10		---	---
11	Total	335.0000	+C11/@SUM($C$4..$C$9)
12			
13		BATTLEFIELD REQUIREMENTS	
14	BRj	BRj VAL	TRANSLATED VALUE
15			
16	BRa1	100.0000	+C16/@SUM($C$16..$C$24)
17	BRa2	90.0000	+C17/@SUM($C$16..$C$24)
18	BRa3	85.0000	+C18/@SUM($C$16..$C$24)
19	BRa4	80.0000	+C19/@SUM($C$16..$C$24)
20	BRa5	70.0000	+C20/@SUM($C$16..$C$24)
21	BRa6	65.0000	+C21/@SUM($C$16..$C$24)
22	BRa7	65.0000	+C22/@SUM($C$16..$C$24)
23	BRa8	55.0000	+C23/@SUM($C$16..$C$24)
24	BRa9	50.0000	+C24/@SUM($C$16..$C$24)
25		---	---
26	Total	660.0000	+C26/@SUM($C$16..$C$24)

Translation of TEi and BRj Values.
Table 16.

	A	B	C	D
1	TEi	BRj	TASK	TASK IMPORTANCE
2	TE1	BRa1	1.1.1.1.1	90/8790
3	TE1	BRa1	1.1.1.1.2	90/8790
4	TE1	BRa1	1.1.1.2	70/8790
5	TE1	BRa1	1.1.2	60/8790
6	TE1	BRa1	1.1.3	100/8790
7	TE1	BRa1	1.1.4	40/8790

Translation of TI Values.
Table 17.

	A	B	C	D	E	F
1	TEi	BRj	D/E	ID	TASK	D/E VALUE
2	TE1	BRa1	D	a1	1.1.1.1.1	70/8810
3	TE1	BRa1	D	a2	1.1.1.1.1	30/8810
4	TE1	BRa1	D	a6	1.1.1.2	10/8810
5	TE1	BRa1	D	a7	1.1.1.2	10/8810
6	TE1	BRa1	D	a8	1.1.1.2	30/8810
7	TE1	BRa1	D	a10	1.1.3	20/8810

Translation of DE Values
Table 18.

The relationship of the branch segments forming a path on the multiple attribute decision tree, or more precisely the values assigned to those segments, is a multiplicative one. Regardless of the conditionality of the segment relationships the multiplicative property applies and the value of a path is the product of the translated values of its segments. That is, if segment 1 has the value A, segment 2 the value B, and segment 3 the value C, then the value of the path formed by the segments 1, 2, and 3 (in order) has the value A times B times C. Numerically, if A = .2, B = .3, and C = .5, then the path has the value (.2)(.3)(.5) = .03.

A previous illustration of the revised multiple attribute decision tree, resulting from the CAC senior leadership decision to weight TVk and DEk differently, shows that one decision tree is generated for the task value and a separate decision tree is generated for the degradation/enhancement value. The relationship of the two decision trees is additive, and related values, i.e., values related to a common TEi-BRj-TASK path, are combined in a weighted sum.

For each branch on the task decision tree a Task Value (TVk) is calculated using the simple multiplicative relationship expressed in this computational formula.

$$(TEi)(BRj)(TIk) = TVk$$

where i = 1, ..., 7; j = a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5; k = task

number, e.g., 4.1.1.1. As an example, suppose i = 1, j = a4, and k = 1.1.1.2. The path under consideration is TE1-BRa4-1.1.1.2 and the TVk associated with this path is

$$\begin{aligned} TV[1.1.1.2] &= (TE1)(BRa4)(TI[1.1.1.2]) \\ &= (90/335)(80/660)(90/8720) \\ &= 0.0003361 \end{aligned}$$

Similarly, for each path on the capability issue decision tree, a Degradation/Enhancement value (DEk) was computed. The formula is

$$(TEi)(BRj)(CIk) = DEk$$

where i = 1, ..., 7; j = a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5; k = task number, e.g., 4.1.1.1. As an example, suppose i = 1, j = a4, and k = 1.1.1.2. The path under consideration is TE1-BRa4-1.1.1.2 and the DEk associated with this path is

$$\begin{aligned} DE[1.1.1.2] &= (TE1)(BRa4)(CI[1.1.1.2]) \\ &= (90/335)(80/660)(70/8810) \\ &= 0.0002587 \end{aligned}$$

Illustrations of these computations as accomplished in the spreadsheet file are shown in Tables 19 and 20.

	A	B	C	D
1	TEi	BRj	TASK	TVk
2	TE1	BRE1	1.1.1.1.1	90/335*100/660*90/8790
3	TE1	BRE1	1.1.1.1.2	90/335*100/660*90/8790
4	TE1	BRE1	1.1.1.2	90/335*100/660*70/8790
5	TE1	BRE1	1.1.2	90/335*100/660*60/8790
6	TE1	BRE1	1.1.3	90/335*100/660*100/8790
7	TE1	BRE1	1.1.4	90/335*100/660*40/8790
8	TE1	BRE1	1.2.1.1.1	90/335*100/660*90/8790
9	TE1	BRE1	1.2.1.1.2	90/335*100/660*70/8790
10	TE1	BRE1	1.2.1.2	90/335*100/660*100/8790
11	TE1	BRE1	1.3.1	90/335*100/660*80/8790

Calculation of TVk
Table 19.

Once the individual path TVk values were computed, it was possible to collect like tasks and calculate an overall TVk by combining all values related to the same task. A simple average of these values was taken to develop an interim list of ordered essential tasks. The computational formula used was

$$\text{Overall TVk} = (\text{TVk})/n$$

where k = task number and n = the number of paths associated with k.

	A	B	C	D	E	F
1	TEi	BRj	D/E	ID	TASK	DEk
2	TE1	BRa1	D	a1	1.1.1.1.1	90/335*100/660*70/8810
3	TE1	BRa1	D	a2	1.1.1.1.1	90/335*100/660*30/8810
4	TE1	BRa1	D	a6	1.1.1.2	90/335*100/660*10/8810
5	TE1	BRa1	D	a7	1.1.1.2	90/335*100/660*10/8810
6	TE1	BRa1	D	a8	1.1.1.2	90/335*100/660*30/8810
7	TE1	BRa1	D	a10	1.1.3	90/335*100/660*20/8810
8	TE1	BRa1	D	a11	1.1.3	90/335*100/660*10/8810
9	TE1	BRa1	D	a12	1.1.3	90/335*100/660*10/8810
10	TE1	BRa1	D	a194	1.1.3	90/335*100/660*60/8810
11	TE1	BRa1	D	a13	1.1.4	90/335*100/660*20/8810
12	TE1	BRa1	D	a14	1.2.1.1.1	90/335*100/660*60/8810
13	TE1	BRa1	D	a15	1.2.1.2	90/335*100/660*20/8810
14	TE1	BRa1	D	a16	1.2.1.2	90/335*100/660*70/8810
15	TE1	BRa1	D	a17	1.2.1.2	90/335*100/660*70/8810

Calculation of DEk
Table 20.

Following the computation of all TVk and DEk values, the aligning of corresponding branches of the two decision trees was done. This resulted in approximately six thousand pairings of TVk and DEk values. The capability value (CVk) was calculated for each aligned pair. This was done using a weighted factoring of the paired TVk and DEk values. The general algorithm is illustrated below.

$$CVk = a(TEi)(BRj)(TVk) + b(TEi)(BRj)(DEk)$$

where a and b are the weighting factors; i = 1,...,7; j = a1, ..., a9, b1, ..., b8, c1, ..., c10, d1, ...,d5, e1, ..., e5, f1, ..., f5, g1, ..., g5; k = task number, e.g., 4.1.1.1.

A sensitivity analysis of weighting factors was conducted. The CVk was calculated using weighting factors of 60%-40%, 50%-50%, 40%-60%, and 30%-70%. The issues were placed in order based on descending CVk values. The resulting placements were compared, and it was determined that there was little sensitivity in the range from 60%-40% to 40%-60%. Thus, the CAC senior leadership decision to use a 40%-60% weighting was validated. The specific algorithm used to calculate the CVk was

$$CVk = .4(TEi)(BRj)(TVk) + .6(TEi)(BRj)(DEk)$$

An illustration of its appearance in a spreadsheet file is shown in Table 21.

	A	B	C	D
1	TEi	BRj	TASK	TVk
2	TE1	BRa2	1.1.1.1 A	0.0002500683
3	TE1	BRa3	1.1.1.1 A	0.0003149008
4	TE1	BRa4	1.1.1.1 A	0.0001481886
5	---	---	---	
6	TE1	BRa1	1.1.1.1.1	0.0004167805
7	TE1	BRa1	1.1.1.1.1	0.0004167805
8	TE1	BRa2	1.1.1.1.1	0.0002917464
9	TE1	BRa2	1.1.1.1.1	0.0002917464
10	TE1	BRa3	1.1.1.1.1	0.0003542634
11	TE1	BRa3	1.1.1.1.1	0.0003542634
12	TE1	BRa4	1.1.1.1.1	0.0000000000
13	TE1	BRa5	1.1.1.1.1	0.0002917464
14	TE1	BRa5	1.1.1.1.1	0.0002917464
15	TE1	BRa7	1.1.1.1.1	0.0002709073
16	TE1	BRa7	1.1.1.1.1	0.0002709073
17	TE1	BRa9	1.1.1.1.1	0.0000000000
18	---	---	---	

...	F	G	H	I	...	AA	AB
	D/E	ID	DEk	CVk		.4	.6
	D	a4	0.0000415834	+D3*$AA$2+H3*$AB$2			
	D	a4	0.0000392732	+D4*$AA$2+H4*$AB$2			
	D	a4	0.0000369631	+D5*$AA$2+H5*$AB$2			
	---	---	---	---			
	D	a1	0.0003234267	+D7*$AA$2+H7*$AB$2			
	D	a2	0.0001386115	+D8*$AA$2+H8*$AB$2			
	D	a2	0.0001247503	+D9*$AA$2+H9*$AB$2			
	D	a1	0.0002910840	+D10*$AA$2+H10*$AB$2			
	D	a2	0.0000785465	+D11*$AA$2+H11*$AB$2			
	D	a1	0.0002749127	+D12*$AA$2+H12*$AB$2			
	D	a3	0.0001108892	+D13*$AA$2+H13*$AB$2			
	D	a3	0.0000970280	+D14*$AA$2+H14*$AB$2			
	D	a2	0.0000323427	+D15*$AA$2+H15*$AB$2			
	D	a2	0.0000300325	+D16*$AA$2+H16*$AB$2			
	D	a3	0.0000900974	+D17*$AA$2+H17*$AB$2			
	D	a3	0.0001155095	+D18*$AA$2+H18*$AB$2			
	---	---	---	---			

Computation of CVk
Table 21.

After the six thousand plus CVk values were calculated, the process of collecting like pairs, in this case those pairs associated with the same ID, began. The overall CVk value for a capability issue was the average of the CVk for the ID group. This was a simple average as illustrated by the algorithm below.

$$\text{Overall CVk} = (\text{CVk})/n$$

where n is the number of occurrences of the ID associated with k when k is the task number.

The final algorithm to be discussed is the one that was used to compute the relative order of the consolidated capability issues. In developing this algorithm it was necessary to follow the guidance given by the senior leadership, which was to give some consideration to the number of issues collected under each consolidated capability issue, but not have it be the overriding

factor. In order to satisfy these conditions, the final CVk value was calculated as the average of the sum of the CVk values and the average of the CVk values for the merged issues. The computational formula used was

Final CVk = [(overall CVk) + (overall CVk)/n]/2

where n is the number of individual capability issues contained in a consolidated capability issue.

The ordered list of consolidated capability issues was developed by arranging the final CVk values in descending order. The contents of the spreadsheet file illustrating the final CVk computation are presented in Table 22.

	C	D	E	F	G	H
1	PROP	TASK		CON	D/E	ID
2	CCCA	5.1.2.3		CON 510	D	a100
3	CCL	5.1.2.3		CON 510	D	e60
4	CCCA	5.1.2.3		CON 510	D	b55
5	CCCA	5.1.2.3		CON 510	D	c56
6	CCCA	5.1.2.3		CON 510	D	a1
7	CCH	5.1.2.3		CON 510	D	d39
8	CCCA	5.1.2.3		CON 510	D	c80
9	CCCA	5.1.2.3		CON 510	D	a102
10	CCCA	5.1.2.3		CON 510	D	c5
11	CCCA	5.1.2.3		CON 510	D	c88
12	CCCA	5.1.2.3		CON 510	D	a110

	I	J	K	L
	CVk	AVG CVk	SUMMED CVk	OVERALL CVk
	0.0002415372	@AVG(I2..I12)	@SUM(I2..I12)	(+$J2+$K2)/2
	0.0000754046			
	0.0001334260			
	0.0001350191			
	0.0003195901			
	0.0001608628			
	0.0001604136			
	0.0002897614			
	0.0002106754			
	0.0001737289			
	0.0002978134			

Computation of Overall CVk.
Table 22.

VIII. Example.

A. Data.

The population of Theater/Echelon/Threat (TET) combinations totals four, and each is valued, on a scale from 0 to 100, relative to the others as follows:

TET1	80
TET2	65
TET3	50
TET4	40

The battlefield requirements for each TET combination are valued in the same manner. The population of battlefield requirements varies relative to TETi and is valued relative to it.

TET1	BRa1	90
	BRa2	85
	BRa3	75
	BRa4	65
TET2	BRb1	95
	BRb2	80
	BRb3	75
TET3	BRc1	100
	BRc2	95
	BRc3	80
	BRc4	80
	BRc5	70
TET4	BRd1	100
	BRd2	90
	BRd3	85

The population of battlefield tasks being analyzed is ten (T1, T2, T3, T4, T5, T6, T7, T8, T9, T10). Tasks will be valued

relative to the associated battlefield requirement. For this example, the value of the task will be assigned on the scale from 0 to 100 with 100 being the highest value. The value 1 is reserved for those tasks not assigned a value relative to a given battlefield requirement.

TET1

BRa1		BRa2		BRa3		BRa4	
T1	40	T2	60	T4	100	T3	90
T2	100	T3	60	T5	80	T4	85
T5	80	T5	80	T7	80	T6	80
T6	20	T6	75	T9	75	T9	70
T8	60	T7	40	T10	70	T10	70
T10	55	T9	95				
		T10	35				

TET2

BRb1		BRb2		BRb3	
T2	95	T1	100	T3	95
T4	60	T2	20	T5	100
T7	20	T3	35	T6	85
T10	100	T4	90	T8	80
		T5	40	T9	20
		T6	75	T10	35
		T8	60		
		T10	70		

TET3

BRc1		BRc2		BRc3		BRc4		BRc5	
T4	60	T2	20	T2	60	T3	60	T1	70
T6	100	T4	80	T6	75	T5	80	T3	85
T7	60	T5	75	T7	30	T6	60	T9	50
T8	55	T6	10	T8	50	T8	80		
T10	40	T7	100			T9	95		
		T8	95						
		T10	00						

TET4

BRd1		BRd2		BRd3	
T5	10	T1	100	T6	100
T7	35	T3	20	T7	40
T8	85	T4	60	T9	65
		T5	35		
		T6	30		
		T8	40		
		T9	95		

The degradation or enhancement measure related to a task will be expressed on a scale of 0 to 100. In the example the following degradation/enhancement values were randomly assigned:

TET1

BRa1		BRa2		BRa3		BRa4	
T1	D 40	T7	E 40	T4	D 45	T3	D 95
T5	D 55	T10	E 65	T5	D 80	T9	D 75
T6	E 65			T7	E 60	T10	E 25
T10	D 80			T8	E 85		

TET2

BRb1		BRb2		BRb3	
T7	D 75	T4	D 65	T6	D 90
		T10	D 80		

TET3

BRc1		BRc2		BRc3	BRc4		BRc5	
T6	D 80	T4	D 65		T8	D 55	T2	D 80
		T10	D 70				T7	E 55

TET4

BRd1		BRd2		BRd3	
T5	D 60	T4	E 40	T6	D 85
T7	D 75	T2	D 30	T3	D 75

A conditional relationship between attributes is assumed, that is, the values assigned are conditional upon the preceding attribute. While this in itself is sufficient weighting of attributes, in the actual application it was directed that the task value and degradation/enhancement values were to be weighted 40% and 60%, respectively.

B. Translation.

The translation of raw data values into the format required by the multiple attribute decision tree technique yields the following results.

		Raw Value	Translated Value
	TET1	80	0.340
	TET2	65	0.277
	TET3	50	0.213
	TET4	40	0.170
		235	1.000
TET1	BRa1	90	0.286
	BRa2	85	0.270
	BRa3	75	0.238
	BRa4	65	0.206
		315	1.000
TET2	BRb1	95	0.380
	BRb2	80	0.320
	BRb3	75	0.300
		250	1.000

		Raw Value	Translated Value
TET3	BRc1	100	0.235
	BRc2	95	0.224
	BRc3	80	0.188
	BRc4	80	0.188
	BRc5	70	0.165
		425	1.000
TET4	BRd1	100	0.364
	BRd2	90	0.327
	BRd3	85	0.309
		275	1.000

The translation of task and degradation/enhancement values was accomplished in a different manner as explained earlier. For this example the denominator for the task value translation is 490 and for the degradation/enhancement value translation 270. The resulting translated values follow.

Task

Raw Value	Translated Value	Raw Value	Translated Value
100	0.2040816	95	0.1938776
90	0.1836735	85	0.1734694
80	0.1632653	75	0.1530612
70	0.1428571	65	0.1326531
60	0.1224490	55	0.1122449
50	0.1020408	45	0.0918367
40	0.0816327	35	0.0714286
30	0.0612245	25	0.0510204
20	0.0408163	15	0.0306122
10	0.0204082		

Degradation/Enhancement

Raw Value	Translated Value	Raw Value	Translated Value
100	0.3703704	95	0.3518519
90	0.3333333	85	0.3148148
80	0.2962963	75	0.2777778

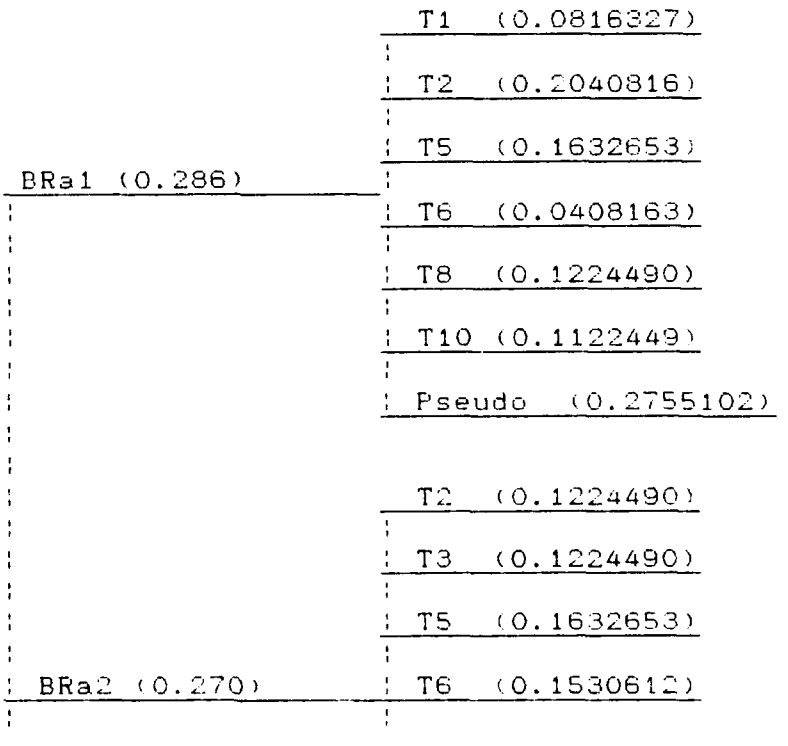
Degradation/Enhancement

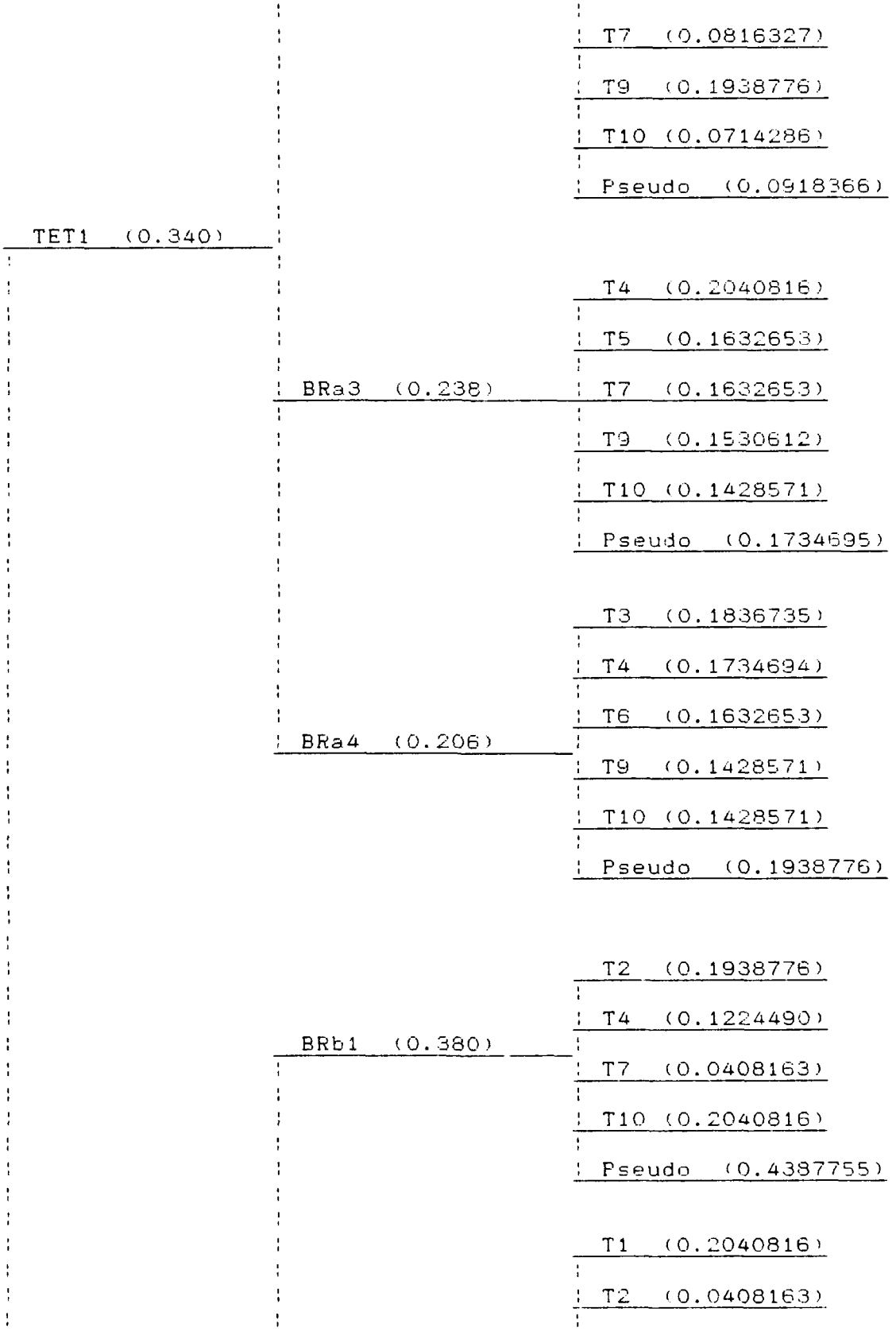
Raw Value	Translated Value	Raw Value	Translated Value
70	0.2592593	65	0.2407407
60	0.2222222	55	0.2037037
50	0.1851852	45	0.1666667
40	0.1481481	35	0.1296296
30	0.1111111	25	0.0925926
20	0.0740741	15	0.0555556
10	0.0370370		

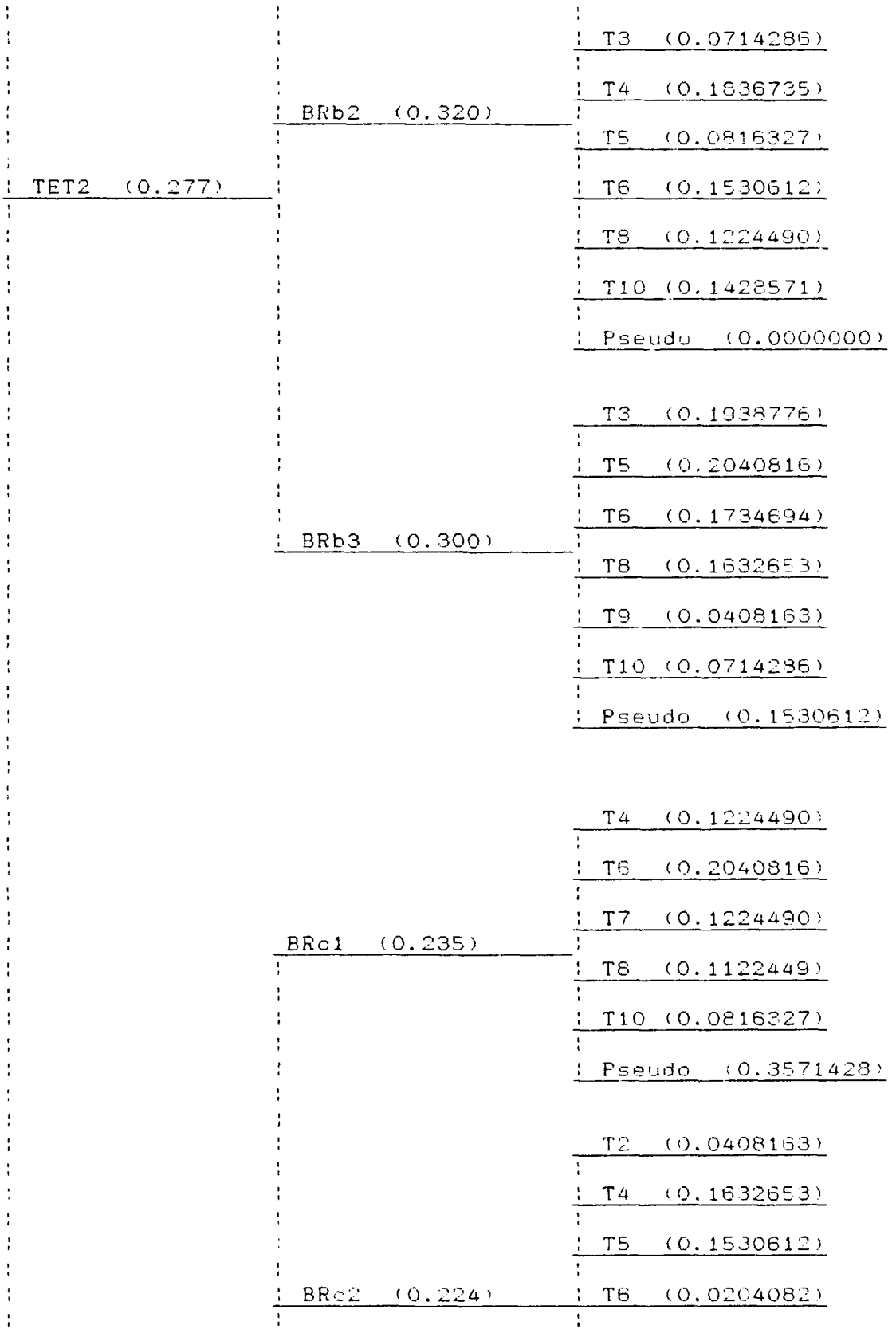
C. Decision Tree.

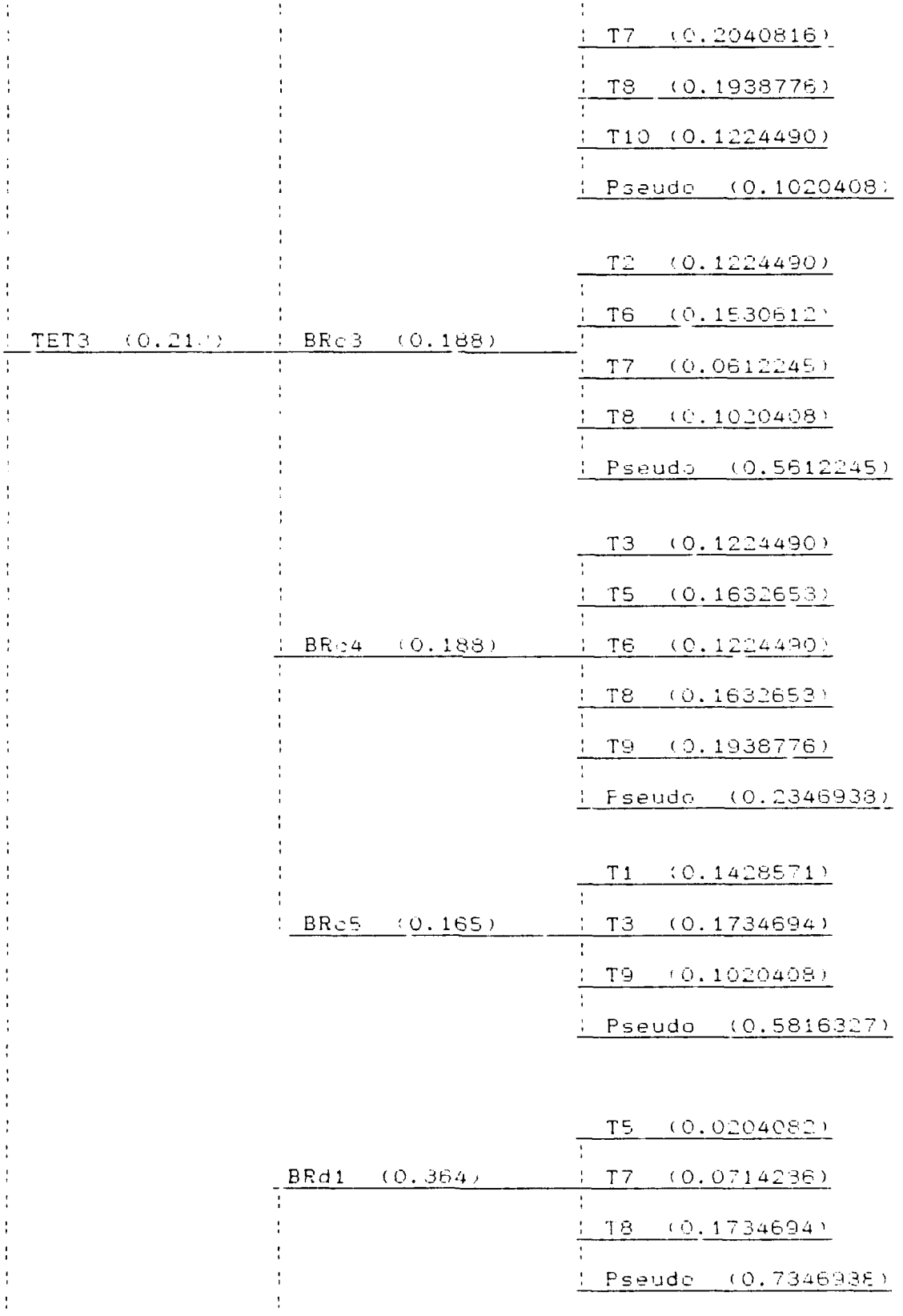
The multiple attribute decision tree is in two parts. The first part is the Task portion of the tree, and the second is the Capability issue portion of the tree. A schematic of the multiple attribute decision tree for this example follows.

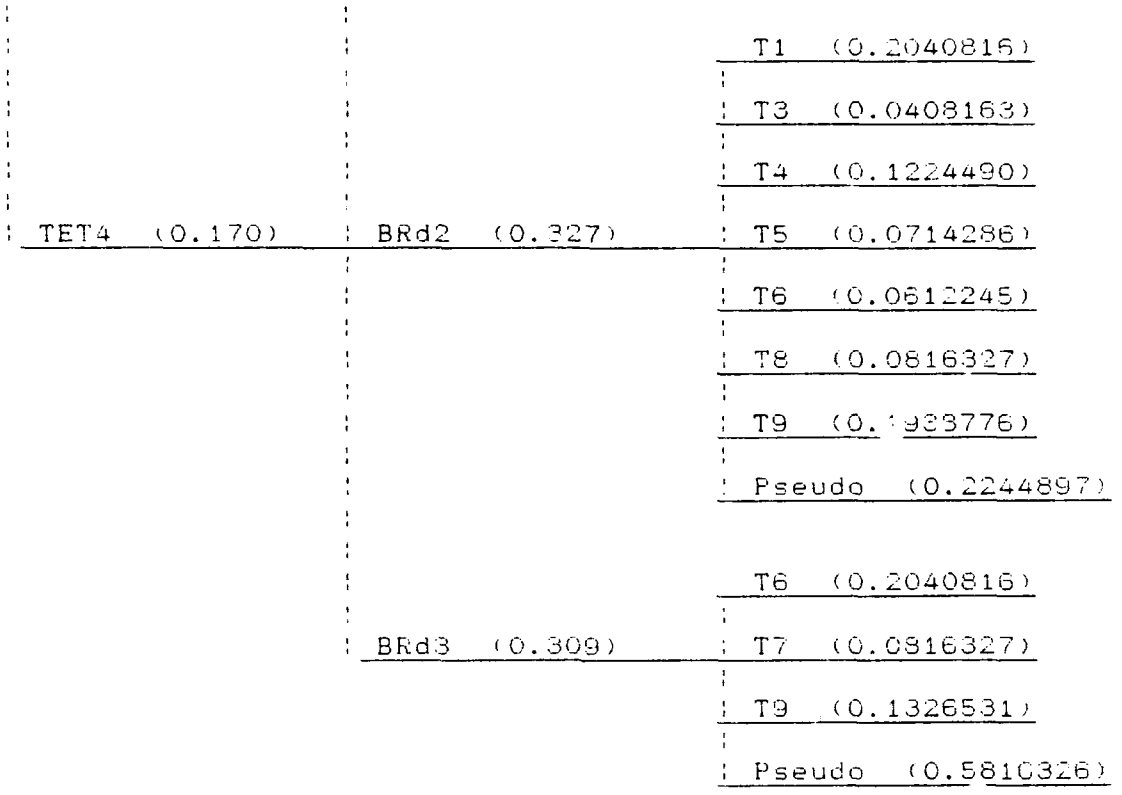
Task Tree



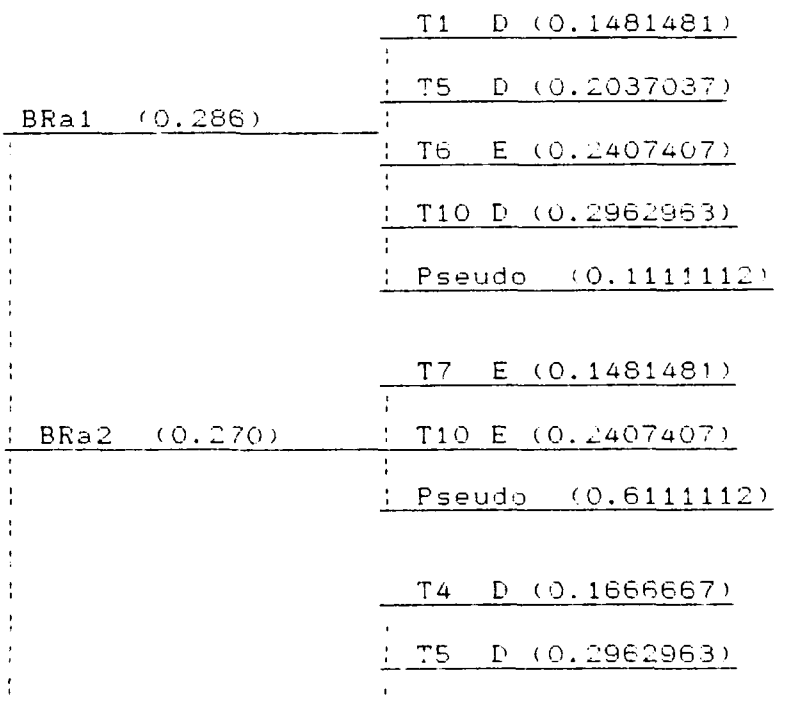

T7 (0.0816327)
T9 (0.1938776)
T10 (0.0714286)
Pseudo (0.0918366)
TET1 (0.340)
T4 (0.2040816)
T5 (0.1632653)
BRa3 (0.238)
T7 (0.1632653)
T9 (0.1530612)
T10 (0.1428571)
Pseudo (0.1734695)
T3 (0.1836735)
T4 (0.1734694)
T6 (0.1632653)
BRa4 (0.206)
T9 (0.1428571)
T10 (0.1428571)
Pseudo (0.1938776)
T2 (0.1938776)
T4 (0.1224490)
BRb1 (0.380)
T7 (0.0408163)
T10 (0.2040816)
Pseudo (0.4387755)
T1 (0.2040816)
T2 (0.0408163)

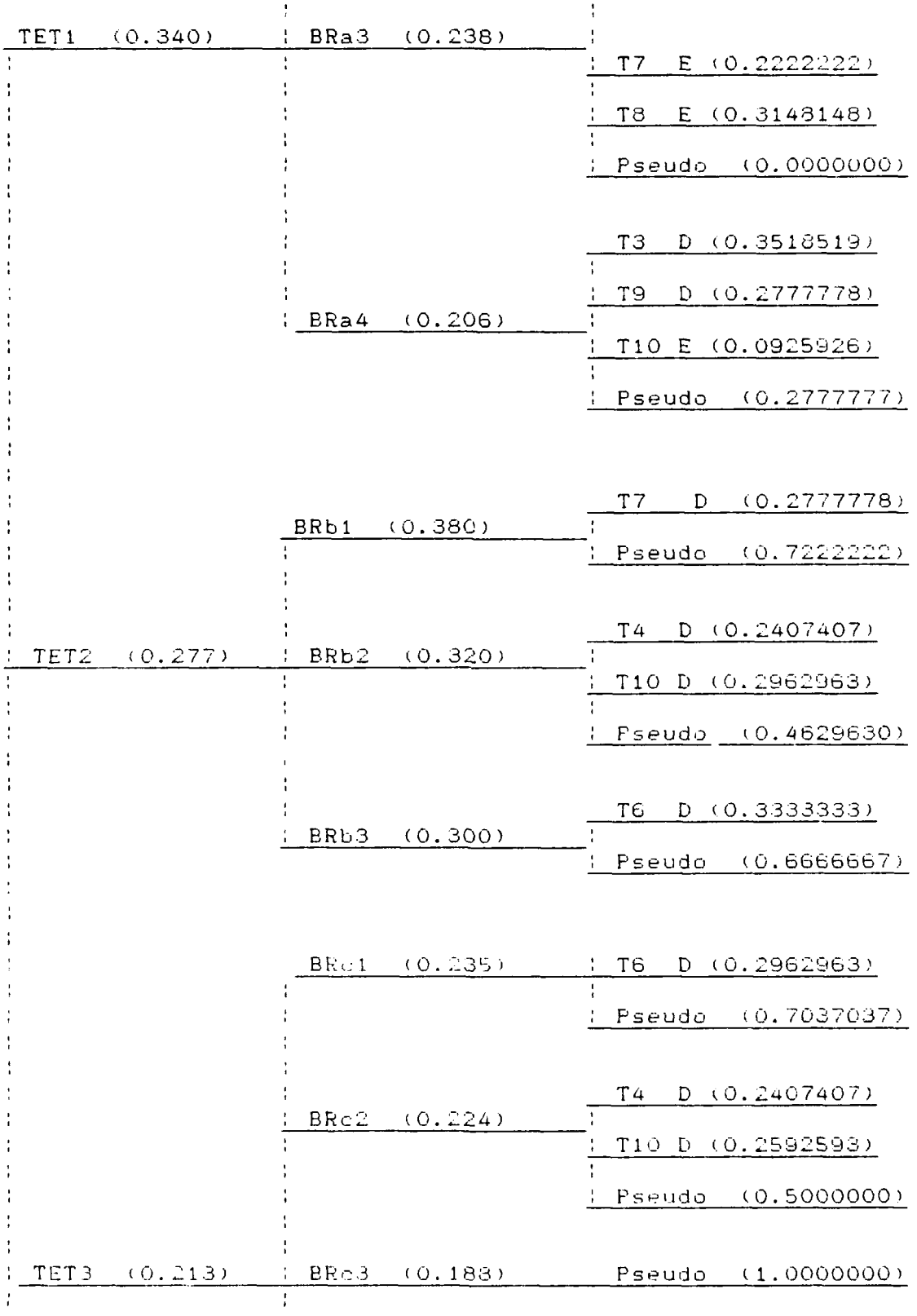

TET2 (0.277)
BRb2 (0.320)
T3 (0.0714286)
T4 (0.1836735)
T5 (0.0816327)
T6 (0.1530612)
T8 (0.1224490)
T10 (0.1428571)
Pseudo (0.0000000)
BRb3 (0.300)
T3 (0.1938776)
T5 (0.2040816)
T6 (0.1734694)
T8 (0.1632653)
T9 (0.0408163)
T10 (0.0714286)
Pseudo (0.1530612)
BRc1 (0.235)
T4 (0.1224490)
T6 (0.2040816)
T7 (0.1224490)
T8 (0.1122449)
T10 (0.0816327)
Pseudo (0.3571428)
BRc2 (0.224)
T2 (0.0408163)
T4 (0.1632653)
T5 (0.1530612)
T6 (0.0204082)

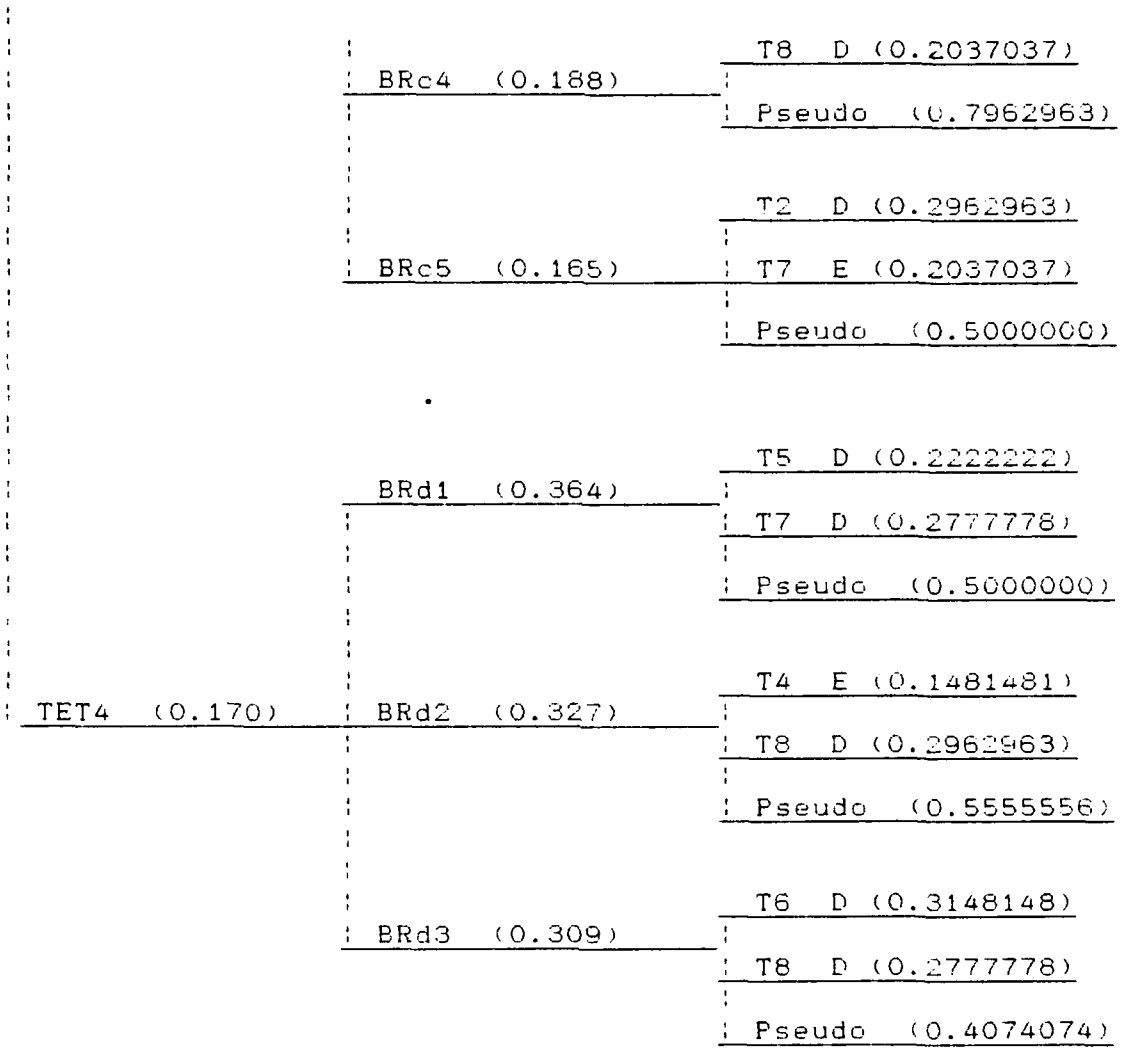

T7 (0.2040816)
T8 (0.1938776)
T10 (0.1224490)
Pseudo (0.1020408)
T2 (0.1224490)
T6 (0.1530612)
TET3 (0.21.)
BRc3 (0.188)
T7 (0.0612245)
T8 (0.1020408)
Pseudo (0.5612245)
T3 (0.1224490)
T5 (0.1632653)
BRc4 (0.188)
T6 (0.1224490)
T8 (0.1632653)
T9 (0.1938776)
Pseudo (0.2346938)
T1 (0.1428571)
BRc5 (0.165)
T3 (0.1734694)
T9 (0.1020408)
Pseudo (0.5816327)
T5 (0.0204082)
BRd1 (0.364)
T7 (0.0714286)
T8 (0.1734694)
Pseudo (0.7346938)



Capability Issue Tree




TET1 (0.340)
BRa3 (0.238)
T7 E (0.2222222)
T8 E (0.3148148)
Pseudo (0.0000000)
T3 D (0.3518519)
T9 D (0.2777778)
BRa4 (0.206)
T10 E (0.0925926)
Pseudo (0.2777777)
T7 D (0.2777778)
BRb1 (0.380)
Pseudo (0.7222222)
T4 D (0.2407407)
TET2 (0.277)
BRb2 (0.320)
T10 D (0.2962963)
Pseudo (0.4629630)
T6 D (0.3333333)
BRb3 (0.300)
Pseudo (0.6666667)
BRc1 (0.235)
T6 D (0.2962963)
Pseudo (0.7037037)
T4 D (0.2407407)
BRc2 (0.224)
T10 D (0.2592593)
Pseudo (0.5000000)
TET3 (0.213)
BRc3 (0.188)
Pseudo (1.0000000)



D. Spreadsheets.

Because the example is small, the large number of files required for the actual project is not necessary. However, one spreadsheet file has been built for each step in the process, and these are displayed in this section.

XDATA.WK1 is the spreadsheet file built to hold all of the raw data. Its composition and contents relative to this example are shown in Table 23.

	A	B	C	D
1	THEATER/ECHELON/THREAT COMBINATIONS			
2				
3	TETi	RAW VALUE		TRANSLATED VALUE
4	TET1	80		0.3404255319
5	TET2	65		0.2765957447
6	TET3	50		0.2127659574
7	TET4	40		0.1702127660
8		---		---
9		235		1.0000000000
10				
11	BATTLEFIELD REQUIREMENTS			
12				
13	BRj	RAW VALUE		TRANSLATED VALUE
14				
15	BRa1	90		0.2857142857
16	BRa2	85		0.2698412698
17	BRa3	75		0.2380952381
18	BRa4	65		0.2063492063
19		---		---
20		315		1.0000000000
23				
24	BRb1	95		0.3800000000
25	BRb2	80		0.3200000000
26	BRb3	75		0.3000000000
27		---		---
28		250		1.0000000000
29				
30	BRc1	100		0.2352941176
31	BRc2	95		0.2235294118
32	BRc3	80		0.1882352941
33	BRc4	80		0.1882352941
34	BRc5	70		0.1647058824
35		---		---
36		425		1.0000000000
37				
38	BRd1	100		0.3636363636
39	BRd2	90		0.3272727273
40	BRd3	85		0.3090909091
41		---		---
42		275		1.0000000000

	F	G	H	I	J	K
1	BATTLEFIELD REQUIREMENT ASSOCIATED TASKS					
2	TASK	BRa1	BRa2	BRa3	BRa4	
3	T1	40	1	1	1	
4	T2	100	60	1	1	
5	T3	1	60	1	90	
6	T4	1	1	100	85	

	F	G	H	I	J	K
7	T5	80	80	80	1	
8	T6	20	75	1	80	
9	T7	1	40	80	1	
10	T8	60	1	1	1	
11	T9	1	95	75	70	
12	T10	55	35	70	70	
13						
14		355	445	405	395	
15		50.7143	55.6250	81.0000	79.0000	
16						
17	TASK	BRb1	BRb2	BRb3		
18	T1	1	100	1		
19	T2	95	20	1		
20	T3	1	35	95		
21	T4	60	90	1		
22	T5	1	40	100		
23	T6	1	75	85		
24	T7	20	1	1		
25	T8	1	60	80		
26	T9	1	1	20		
27	T10	100	70	35		
28						
29		275	490	415		
30		68.7500	61.2500	69.1667		
31						
32	TASK	BRc1	BRc2	BRc3	BRc4	BRc5
33	T1	1	1	1	1	70
34	T2	1	20	60	1	1
35	T3	1	1	1	60	85
36	T4	60	80	1	1	1
37	T5	1	75	1	1	1
38	T6	100	10	75	60	1
39	T7	60	100	30	1	1
40	T8	55	95	50	80	1
41	T9	1	1	1	95	50
42	T10	40	60	1	1	1
43						
44		315	440	215	295	205
45		63.0000	62.8571	53.7500	73.7500	68.3333
46						
47	TASK	BRd1	BRd2	BRd3		
48	T1	1	100	1		
49	T2	1	1	1		
50	T3	1	20	1		
51	T4	1	60	1		
52	T5	10	35	1		
53	T6	1	30	100		
54	T7	35	1	40		
55	T8	85	40	1		
56	T9	1	95	65		
57	T10	1	1	1		
58						
59		130	380	205		
60		43.3333	54.2857	68.3333		

	F	G	H	I	J	K
61						
62						
63		AVERAGE VALUE ASSIGNED TASKS				
64						
65		BRa1	BRa2	BRa3	BRa4	
66		355	445	405	395	
67		50.7143	55.6250	81.0000	79.0000	
68						
69		BRb1	BRb2	BRb3		
70		275	490	415		
71		68.7500	61.2500	69.1667		
72						
73		BRc1	BRc2	BRc3	BRc4	BRc5
74		315	440	215	295	205
75		63.0000	62.8571	53.7500	73.7500	68.3333
76						
77		BRd1	BRd2	BRd3		
78		130	380	205		
79		43.3333	54.2857	68.3333		
80						
81		AVERAGE RANGE 55 to 67 WITH AVERAGE 63.15731				
82		MAXIMUM SUM OF VALUES IS 490				

	M	N	O	P	Q	R	S
1	DEGRADATION/ENHANCEMENT VALUATION						
2	TASK	D/E	BRa1	BRa2	BRa3	BRa4	
3	T1	D	40	0	0	0	
4	T2		0	0	0	0	
5	T3	D	0	0	0	95	
6	T4	D	0	0	45	0	
7	T5	D	55	0	80	0	
8	T6	E	65	0	0	0	
9	T7	E	0	40	60	0	
10	T8	E	0	0	85	0	
11	T9	D	0	0	0	75	
12	T10	D	80	0	0	0	
13	T10	E	0	65	0	25	
14							
15			240	105	270	195	
16			60.0000	52.5000	67.5000	65.0000	
17							
18	TASK	D/E	BRb1	BRb2	BRb3		
19	T1		0	0	0		
20	T2		0	0	0		
21	T3		0	0	0		
22	T4	D	0	65	0		
23	T5		0	0	0		
24	T6	D	0	0	90		
25	T7	D	75	0	0		
26	T8		0	0	0		

	M	N	O	P	Q	R	S
27	T9		0	0	0		
28	T10	D	0	80	0		
29							
30			75	145	90		
31			75	72.5	90		
32							
33	TASK	D/E	BRc1	BRc2	BRc3	BRc4	BRc5
34	T1		0	0	0	0	0
35	T2	D	0	0	0	0	80
36	T3		0	0	0	0	0
37	T4	D	0	65	0	0	0
38	T5		0	0	0	0	0
39	T6	D	80	0	0	0	0
40	T7	E	0	0	0	0	55
41	T8	D	0	0	0	55	0
42	T9		0	0	0	0	0
43	T10	D	0	70	0	0	0
44							
45			80	135	0	55	35
46			80	67.5	0	55	67.5
47							
48	TASK	D/E	BRd1	BRd2	BRd3		
49	T1		0	0	0		
50	T2		0	0	0		
51	T3		0	0	0		
52	T4	E	0	40	0		
53	T5	D	60	0	0		
54	T6	D	0	0	85		
55	T7	D	75	0	0		
56	T8	D	0	80	75		
57	T9		0	0	0		
58	T10		0	0	0		
59							
60			135	120	160		
61			67.5	60	80		
62							
63							
64			AVERAGE DEGRADATION/ENHANCEMENT VALUE				
65							
66			BRa1	BRa2	BRa3	BRa4	
67			240	105	270	195	
68			60.0000	52.5000	67.5000	65.0000	
69							
70			BRb1	BRb2	BRb3		
71			75	145	90		
72			75.0000	72.5000	90.0000		
73							
74			BRc1	BRc2	BRc3	BRc4	BRc5
75			80	135	0	55	135
76			80.0000	67.5000	0.0000	55.0000	67.5000
77							

	M	N	O	P	Q	R	S
78			BRd1	BRd2	BRd3		
79			135	120	160		
80			67.5000	60.0000	80.0000		
81							
82			AVERAGE VALUE RANGE 54 to 79 WITH AVERAGE				
83			MAXIMUM SUM OF VALUES IS 270				

The following ranges are named to facilitate movement of data between spreadsheet files: BRA1 A15..D20; BRA2 F2..J12; BRA3 M2..R13; BRB1 A24..D28; BRB2 F17..I27; BRB3 M18..Q28; BRC1 A30..D34; BRC2 F32..K42; BRD1 A38..D42; BRD2 F47..I57; BRD3 M48..Q58.

XDATA.WK1
Table 23.

Beginning with the extraction of data from the XDATA.WK1 spreadsheet file, the spreadsheet files TETE.WK1, TI-E.WK1, and TVKE.WK1 were built using the macros discussed in the paper. The composition and content of these spreadsheet files are shown in Tables 24, 25, and 26, respectively.

	A	B	C	D	...	AA	AB	AC	AD	AE	AF
1	TE1	BRj	TASK	TASK	IMP		TASK	BRa1	BRa2	BRa3	BRa4	
2	TE1	BRa1	T1		40		T1	40	1	1	1	
3	TE1	BRa1	T2		100		T2	100	60	1	1	
4	TE1	BRa1	T5		80		T3	1	60	1	90	
5	TE1	BRa1	T6		20		T4	1	1	100	85	
6	TE1	BRa1	T8		60		T5	80	80	80	1	
7	TE1	BRa1	T10		55		T6	20	75	1	80	
8	TE1	BRa2	T2		60		T7	1	40	80	1	
9	TE1	BRa2	T3		60		T8	60	1	1	1	
10	TE1	BRa2	T5		80		T9	1	95	75	70	
11	TE1	BRa2	T6		75		T10	55	35	70	70	
12	TE1	BRa2	T7		40							
13	TE1	BRa2	T9		95		TASK	BRb1	BRb2	BRb3		
14	TE1	BRa2	T10		35		T1	1	100	1		
15	TE1	BRa3	T4		100		T2	95	20	1		
16	TE1	BRa3	T5		80		T3	1	35	95		
17	TE1	BRa3	T7		80		T4	60	90	1		
18	TE1	BRa3	T9		75		T5	1	40	100		
19	TE1	BRa3	T10		70		T6	1	75	85		
20	TE1	BRa4	T3		90		T7	20	1	1		
21	TE1	BRa4	T4		85		T8	1	60	80		
22	TE1	BRa4	T6		80		T9	1	1	20		
23	TE1	BRa4	T9		70		T10	100	70	35		

	A	B	C	D
24	TE1	BRa4	T10	70
25	TE2	BRb1	T2	95
26	TE2	BRb1	T4	60
27	TE2	BRb1	T7	20
28	TE2	BRb1	T10	100
29	TE2	BRb2	T1	100
30	TE2	BRb2	T2	20
31	TE2	BRb2	T3	35
32	TE2	BRb2	T4	90
33	TE2	BRb2	T5	40
34	TE2	BRb2	T6	75
35	TE2	BRb2	T8	60
36	TE2	BRb2	T10	70
37	TE2	BRb3	T3	95
38	TE2	BRb3	T5	100
39	TE2	BRb3	T6	85
40	TE2	BRb3	T8	80
41	TE2	BRb3	T9	20
42	TE2	BRb3	T10	35
43	TE3	BRc1	T4	60
44	TE3	BRc1	T6	100
45	TE3	BRc1	T7	60
46	TE3	BRc1	T8	55
47	TE3	BRc1	T10	40
48	TE3	BRc2	T2	20
49	TE3	BRc2	T4	80
50	TE3	BRc2	T5	75
51	TE3	BRc2	T6	10
52	TE3	BRc2	T7	100
53	TE3	BRc2	T8	95
54	TE3	BRc2	T10	60
55	TE3	BRc3	T2	60
56	TE3	BRc3	T6	75
57	TE3	BRc3	T7	30
58	TE3	BRc3	T8	50
59	TE3	BRc4	T3	60
60	TE3	BRc4	T6	60
61	TE3	BRc4	T8	80
62	TE3	BRc4	T9	95
63	TE3	BRc5	T1	70
64	TE3	BRc5	T3	85
65	TE3	BRc5	T9	50
66	TE4	BRd1	T5	10
67	TE4	BRd1	T7	35
68	TE4	BRd1	T8	85
69	TE4	BRd2	T1	100
70	TE4	BRd2	T3	20
71	TE4	BRd2	T4	60
72	TE4	BRd2	T5	35
73	TE4	BRd2	T6	30
74	TE4	BRd2	T8	40

...

	AA	AB	AC	AD	AE	AF
TASK	BRc1	BRc2	BRc3	BRc4	BRc5	
T1	1	1	1	1	70	
T2	1	20	60	1	1	
T3	1	1	1	60	85	
T4	60	80	1	1	1	
T5	1	75	1	1	1	
T6	100	10	75	60	1	
T7	60	100	30	1	1	
T8	55	95	50	80	1	
T9	1	1	1	95	50	
T10	40	60	1	1	1	

TASK	BRd1	BRd2	BRd3
T1	1	100	1
T2	1	1	1
T3	1	20	1
T4	1	60	1
T5	10	35	1
T6	1	30	100
T7	35	1	40
T8	85	40	1
T9	1	95	65
T10	1	1	1

	A	B	C	D	...	AA	AB	AC	AD	AE	AF
75	TE4	BRd2	T9	95							
76	TE4	BRd3	T6	100							
77	TE4	BRd3	T7	40							
78	TE4	BRd3	T9	65							

TETE.WK1
Table 24.

	A	B	C	D
1	TEi	BRj	TASK	TASK IMP
2	TE1	BRa1	T1	0.0816326531
3	TE1	BRa1	T2	0.2040816327
4	TE1	BRa1	T5	0.1632653061
5	TE1	BRa1	T6	0.0408163265
6	TE1	BRa1	T8	0.1224489796
7	TE1	BRa1	T10	0.1122448980
8	TE1	BRa2	T2	0.1224489796
9	TE1	BRa2	T3	0.1224489796
10	TE1	BRa2	T5	0.1632653061
11	TE1	BRa2	T6	0.1530612245
12	TE1	BRa2	T7	0.0816326531
13	TE1	BRa2	T9	0.1938775510
14	TE1	BRa2	T10	0.0714285714
15	TE1	BRa3	T4	0.2040816327
16	TE1	BRa3	T5	0.1632653061
17	TE1	BRa3	T7	0.1632653061
18	TE1	BRa3	T9	0.1530612245
19	TE1	BRa3	T10	0.1428571429
20	TE1	BRa4	T3	0.1836734694
21	TE1	BRa4	T4	0.1734693878
22	TE1	BRa4	T6	0.1632653061
23	TE1	BRa4	T9	0.1428571429
24	TE1	BRa4	T10	0.1428571429
25	TE2	BRb1	T2	0.1938775510
26	TE2	BRb1	T4	0.1224489796
27	TE2	BRb1	T7	0.0408163265
28	TE2	BRb1	T10	0.2040816327
29	TE2	BRb2	T1	0.2040816327
30	TE2	BRb2	T2	0.0408163265
31	TE2	BRb2	T3	0.0714285714
32	TE2	BRb2	T4	0.1836734694
33	TE2	BRb2	T5	0.0816326531
34	TE2	BRb2	T6	0.1530612245
35	TE2	BRb2	T8	0.1224489796
36	TE2	BRb2	T10	0.1428571429
37	TE2	BRb3	T3	0.1938775510
38	TE2	BRb3	T5	0.2040816327
39	TE2	BRb3	T6	0.1734693878
40	TE2	BRb3	T8	0.1632653061
41	TE2	BRb3	T9	0.0408163265

	A	B	C	D
42	TE2	BRb3	T10	0.0714285714
43	TE3	BRc1	T4	0.1224489796
44	TE3	BRc1	T6	0.2040816327
45	TE3	BRc1	T7	0.1224489796
46	TE3	BRc1	T8	0.1122448980
47	TE3	BRc1	T10	0.0816326531
48	TE3	BRc2	T2	0.0408163265
49	TE3	BRc2	T4	0.1632653061
50	TE3	BRc2	T5	0.1530612245
51	TE3	BRc2	T6	0.0204081633
52	TE3	BRc2	T7	0.2040816327
53	TE3	BRc2	T8	0.1938775510
54	TE3	BRc2	T10	0.1224489796
55	TE3	BRc3	T2	0.1224489796
56	TE3	BRc3	T6	0.1530612245
57	TE3	BRc3	T7	0.0612244898
58	TE3	BRc3	T8	0.1020408163
59	TE3	BRc4	T3	0.1224489796
60	TE3	BRc4	T6	0.1224489796
61	TE3	BRc4	T8	0.1632653061
62	TE3	BRc4	T9	0.1938775510
63	TE3	BRc5	T1	0.1428571429
64	TE3	BRc5	T3	0.1734693878
65	TE3	BRc5	T9	0.1020408163
66	TE4	BRd1	T5	0.0204081633
67	TE4	BRd1	T7	0.0714285714
68	TE4	BRd1	T8	0.1734693878
69	TE4	BRd2	T1	0.2040816327
70	TE4	BRd2	T3	0.0408163265
71	TE4	BRd2	T4	0.1224489796
72	TE4	BRd2	T5	0.0714285714
73	TE4	BRd2	T6	0.0612244898
74	TE4	BRd2	T8	0.0816326531
75	TE4	BRd2	T9	0.1938775510
76	TE4	BRd3	T6	0.2040816327
77	TE4	BRd3	T7	0.0816326531
78	TE4	BRd3	T9	0.1326530612

TI-E.WK1
Table 25.

	A	B	C	D
1	TASK	IMPORTANCE	VALUATION	
2	TEi	BRj	TASK	TVk
3	TE1	BRa1	T1	0.0079399541
4	TE1	BRa1	T2	0.0198498852
5	TE1	BRa1	T5	0.0158799082
6	TE1	BRa1	T6	0.0039699770
7	TE1	BRa1	T8	0.0119099311
8	TE1	BRa1	T10	0.0109174369

	A	B	C	D
9	TE1	BRa2	T2	0.0112482683
10	TE1	BRa2	T3	0.0112482683
11	TE1	BRa2	T5	0.0149976911
12	TE1	BRa2	T6	0.0140603354
13	TE1	BRa2	T7	0.0074988455
14	TE1	BRa2	T9	0.0178097581
15	TE1	BRa2	T10	0.0065614898
16	TE1	BRa3	T4	0.0165415710
17	TE1	BRa3	T5	0.0132332568
18	TE1	BRa3	T7	0.0132332568
19	TE1	BRa3	T9	0.0124061783
20	TE1	BRa3	T10	0.0115790997
21	TE1	BRa4	T3	0.0129024254
22	TE1	BRa4	T4	0.0121856240
23	TE1	BRa4	T6	0.0114688226
24	TE1	BRa4	T9	0.0100352198
25	TE1	BRa4	T10	0.0100352198
26	TE2	BRb1	T2	0.0203777681
27	TE2	BRb1	T4	0.0128701693
28	TE2	BRb1	T7	0.0042900564
29	TE2	BRb1	T10	0.0214502822
30	TE2	BRb2	T1	0.0180633956
31	TE2	BRb2	T2	0.0036126791
32	TE2	BRb2	T3	0.0063221884
33	TE2	BRb2	T4	0.0162570560
34	TE2	BRb2	T5	0.0072253582
35	TE2	BRb2	T6	0.0135475467
36	TE2	BRb2	T8	0.0108380373
37	TE2	BRb2	T10	0.0126443769
38	TE2	BRb3	T3	0.0123751628
39	TE2	BRb3	T5	0.2040816327
40	TE2	BRb3	T6	0.0143942683
41	TE2	BRb3	T8	0.0135475467
42	TE2	BRb3	T9	0.0033868867
43	TE2	BRb3	T10	0.0059270517
44	TE3	BRc1	T4	0.0061301116
45	TE3	BRc1	T6	0.0102168527
46	TE3	BRc1	T7	0.0061301116
47	TE3	BRc1	T8	0.0056192690
48	TE3	BRc1	T10	0.0040867411
49	TE3	BRc2	T2	0.0019412020
50	TE3	BRc2	T4	0.0077648081
51	TE3	BRc2	T5	0.0072795075
52	TE3	BRc2	T6	0.0009706010
53	TE3	BRc2	T7	0.0097060101
54	TE3	BRc2	T8	0.0092207096
55	TE3	BRc2	T10	0.0058236060
56	TE3	BRc3	T2	0.0049040893
57	TE3	BRc3	T6	0.0061301116
58	TE3	BRc3	T7	0.0024520446
59	TE3	BRc3	T8	0.0040867411

	A	B	C	D
60	TE3	BRc4	T3	0.0049040893
61	TE3	BRc4	T6	0.0049040893
62	TE3	BRc4	T8	0.0065387857
63	TE3	BRc4	T9	0.0077648081
64	TE3	BRc5	T1	0.0050062578
65	TE3	BRc5	T3	0.0060790274
66	TE3	BRc5	T9	0.0035758984
67	TE4	BRd1	T5	0.0012631745
68	TE4	BRd1	T7	0.0044211108
69	TE4	BRd1	T8	0.0107369834
70	TE4	BRd2	T1	0.0113685706
71	TE4	BRd2	T3	0.0022737141
72	TE4	BRd2	T4	0.0068211424
73	TE4	BRd2	T5	0.0039789997
74	TE4	BRd2	T6	0.0034105712
75	TE4	BRd2	T8	0.0045474283
76	TE4	BRd2	T9	0.0108001421
77	TE4	BRd3	T6	0.0107369834
78	TE4	BRd3	T7	0.0042947934
79	TE4	BRd3	T9	0.0069790392

TVKE.WK1
Table 26.

Again, beginning with extracted data from XDATA.WK1, the spreadsheet files to calculate the degradation/enhancement values were built using the macros discussed. The composition of DETE.WK1, DE-E.WK1, and DEKE.WK1 spreadsheet files are shown in Tables 27, 28, and 29, respectively.

	A	B	C	D	E	F
1	TEi	BRj	TASK	D/E	ID	D/E VALUE
2	TE1	BRa1	T1	D	a1	40
3	TE1	BRa1	T5	D	a4	55
4	TE1	BRa1	T6	E	a5	65
5	TE1	BRa1	T10	D	a9	80
6	TE1	BRa2	T7	E	a6	40
7	TE1	BRa2	T10	E	a10	65
8	TE1	BRa3	T4	D	a3	45
9	TE1	BRa3	T5	D	a4	80
10	TE1	BRa3	T7	E	a6	60
11	TE1	BRa3	T8	E	a7	85
12	TE1	BRa4	T3	D	a2	95
13	TE1	BRa4	T9	D	a8	75
14	TE1	BRa4	T10	E	a10	25

	A	B	C	D	E	F
15	TE2	BRb1	T7	D	b3	75
16	TE2	BRb2	T4	D	b1	65
17	TE2	BRb2	T10	D	b4	80
18	TE2	BRb3	T6	D	b2	90
19	TE3	BRc1	T6	D	c3	80
20	TE3	BRc2	T4	D	c2	65
21	TE3	BRc2	T10	D	c6	70
22	TE3	BRc4	T8	D	c5	55
23	TE3	BRc5	T2	D	c1	80
24	TE3	BRc5	T7	E	c4	55
25	TE4	BRd1	T5	D	d2	60
26	TE4	BRd1	T7	D	d4	75
27	TE4	BRd2	T4	E	d1	40
28	TE4	BRd2	T8	D	d5	80
29	TE4	BRd3	T6	D	d3	85
30	TE4	BRd3	T8	D	d6	75

...	AA	AB	AC	AD	AE	AF	AG	AH
1	DEGRADATION/ENHANCEMENT							
2	TASK	D/E	ID	BRa1	BRa2	BRa3	BRa4	
3	T1	D	a1	40	0	0	0	
4	T2			0	0	0	0	
5	T3	D	a2	0	0	0	95	
6	T4	D	a3	0	0	45	0	
7	T5	D	a4	55	0	80	0	
8	T6	E	a5	65	0	0	0	
9	T7	E	a6	0	40	60	0	
10	T8	E	a7	0	0	85	0	
11	T9	D	a8	0	0	0	75	
12	T10	D	a9	80	0	0	0	
13	T10	E	a10	0	65	0	25	
14								
15	TASK	D/E	ID	BRb1	BRb2	BRb3		
16	T1			0	0	0		
17	T2			0	0	0		
18	T3			0	0	0		
19	T4	D	b1	0	65	0		
20	T5			0	0	0		
21	T6	D	b2	0	0	90		
22	T7	D	b3	75	0	0		
23	T8			0	0	0		
24	T9			0	0	0		
25	T10	D	b4	0	80	0		
26								
27	TASK	D/E	ID	BRc1	BRc2	BRc3	BRc4	BRc5
28	T1			0	0	0	0	0
29	T2	D	c1	0	0	0	0	80
30	T3			0	0	0	0	0
31	T4	D	c2	0	65	0	0	0
32	T5			0	0	0	0	0

...	AA	AB	AC	AD	AE	AF	AG	AH
33	T6	D	c3	80	0	0	0	0
34	T7	E	c4	0	0	0	0	55
35	T8	D	c5	0	0	0	55	0
36	T9			0	0	0	0	0
37	T10	D	c6	0	70	0	0	0
38								
39	TASK	D/E	ID	BRd1	BRd2	BRd3		
40	T1			0	0	0		
41	T2			0	0	0		
42	T3			0	0	0		
43	T4	E	d1	0	40	0		
44	T5	D	d2	60	0	0		
45	T6	D	d3	0	0	85		
46	T7	D	d4	75	0	0		
47	T8	D	d5	0	80	75		
48	T9			0	0	0		
49	T10			0	0	0		

DETE.WK1
Table 27.

	A	B	C	D	E	F	
1	TEi	BRj	TASK	D/E	ID	D/E	VALUE
2	TE1	BRa1	T1	D	a1		40
3	TE1	BRa1	T5	D	a4		55
4	TE1	BRa1	T6	E	a5		65
5	TE1	BRa1	T10	D	a9		80
6	TE1	BRa2	T7	E	a6		40
7	TE1	BRa2	T10	E	a10		65
8	TE1	BRa3	T4	D	a3		45
9	TE1	BRa3	T5	D	a4		80
10	TE1	BRa3	T7	E	a6		60
11	TE1	BRa3	T8	E	a7		85
12	TE1	BRa4	T3	D	a2		95
13	TE1	BRa4	T9	D	a8		75
14	TE1	BRa4	T10	E	a10		25
15	TE2	BRb1	T7	D	b3		75
16	TE2	BRb2	T4	D	b1		65
17	TE2	BRb2	T10	D	b4		80
18	TE2	BRb3	T6	D	b2		90
19	TE3	BRc1	T6	D	c3		80
20	TE3	BRc2	T4	D	c2		65
21	TE3	BRc2	T10	D	c6		70
22	TE3	BRc4	T8	D	c5		55
23	TE3	BRc5	T2	D	c1		80
24	TE3	BRc5	T7	E	c4		55
25	TE4	BRd1	T5	D	d2		60
26	TE4	BRd1	T7	D	d4		75
27	TE4	BRd2	T4	E	d1		40

	A	B	C	D	E	F
28	TE4	BRd2	T8	D	d5	80
29	TE4	BRd3	T6	D	d3	85
30	TE4	BRd3	T8	D	d6	75

DE-E.WK1
Table 28.

	A	B	C	D	E	F
1	TEi	BRj	TASK	D/E	ID	DEk
2	TE1	BRa1	T1	D	a1	0.0144095463
3	TE1	BRa1	T5	D	a4	0.0198131262
4	TE1	BRa1	T6	E	a5	0.0234155128
5	TE1	BRa1	T10	D	a9	0.0288190926
6	TE1	BRa2	T7	E	a6	0.0136090160
7	TE1	BRa2	T10	E	a10	0.0221146510
8	TE1	BRa3	T4	D	a3	0.0135089497
9	TE1	BRa3	T5	D	a4	0.0240159105
10	TE1	BRa3	T7	E	a6	0.0180119329
11	TE1	BRa3	T8	E	a7	0.0255169049
12	TE1	BRa4	T3	D	a2	0.0247163746
13	TE1	BRa4	T9	D	a8	0.0195129273
14	TE1	BRa4	T10	E	a10	0.0065043091
15	TE2	BRb1	T7	D	b3	0.0231716012
16	TE2	BRb2	T4	D	b1	0.0213081166
17	TE2	BRb2	T10	D	b4	0.0262253743
18	TE2	BRb3	T6	D	b2	0.0276595745
19	TE3	BRc1	T6	D	c3	0.0148333565
20	TE3	BRc2	T4	D	c2	0.0114494971
21	TE3	BRc2	T10	D	c6	0.0123302276
22	TE3	BRc4	T8	D	c5	0.0081583461
23	TE3	BRc5	T2	D	c1	0.0103833496
24	TE3	BRc5	T7	E	c4	0.0071385528
25	TE4	BRd1	T5	D	d2	0.0137545669
26	TE4	BRd1	T7	D	d4	0.0171932087
27	TE4	BRd2	T4	E	d1	0.0082527402
28	TE4	BRd2	T8	D	d5	0.0165054803
29	TE4	BRd3	T6	D	d3	0.0165627910
30	TE4	BRd3	T8	D	d6	0.0146142274

DEKE.WK1
Table 29.

Following the completion of the TEKE.WK1 and DEKE.WK1 spreadsheet files, the CVKE.WK1 spreadsheet file was built. Since the example has a small number of entries, this file contains much of what was found in a series of CVK#-##.WK1 spreadsheet files in

the actual project. A list of the spreadsheet files constructed during the prioritization process is provided in Appendix G. The contents of the CVKE.WK1 spreadsheet file is shown in Table 30.

	A	B	C	D	E	F	G
1	TEi	BRj	TASK	TVk	D/E	ID	DEk
2	TE1	BRa1	T1	0.0079399541	D	a1	0.0144095463
3	----------				----------		
4	TE3	BRc5	T2	0.0000000000	D	c1	0.0103833496
5	----------				----------		
6	TE1	BRa4	T3	0.0129024254	D	a2	0.0247163746
7	----------				----------		
8	TE1	BRa3	T4	0.0165415710	D	a3	0.0135089497
9	TE2	BRb2	T4	0.0162570560	D	b1	0.0213081166
10	TE3	BRc2	T4	0.0077648081	D	c2	0.0114494971
11	TE4	BRd2	T4	0.0068211424	E	d1	0.0082527402
12	----------				----------		
13	TE1	BRa1	T5	0.0158799082	D	a4	0.0198131262
14	TE1	BRa3	T5	0.0132332568	D	a4	0.0240159105
15	TE4	BRd1	T5	0.0012631745	D	d2	0.0137545669
16	----------				----------		
17	TE1	BRa1	T6	0.0039699770	E	a5	0.0234155128
18	TE2	BRb3	T6	0.0143942683	D	b2	0.0276595745
19	TE3	BRc1	T6	0.0102168527	D	c3	0.0148333565
20	TE4	BRd3	T6	0.0107369834	D	d3	0.0165627910
21	----------				----------		
22	TE1	BRa2	T7	0.0074988455	E	a6	0.0136090160
23	TE1	BRa3	T7	0.0132332568	E	a6	0.0180119329
24	TE2	BRb1	T7	0.0042900564	D	b3	0.0231716012
25	TE3	BRc5	T7	0.0000000000	E	c4	0.0071385528
26	TE4	BRd1	T7	0.0044211108	D	d4	0.0171932087
27	----------				----------		
28	TE1	BRa3	T8	0.0000000000	E	a7	0.0255169049
29	TE3	BRc4	T8	0.0065387857	D	c5	0.0081583461
30	TE4	BRd2	T8	0.0045474283	D	d5	0.0165054803
31	TE4	BRd3	T8	0.0000000000	D	d6	0.0146142274
32	----------				----------		
33	TE1	BRa4	T9	0.0100352198	D	a8	0.0195129273
34	----------				----------		
35	TE1	BRa2	T10	0.0065614898	E	a10	0.0221146510
36	TE1	BRa4	T10	0.0100352198	E	a10	0.0065043091
37	TE1	BRa1	T10	0.0109174369	D	a9	0.0288190926
38	TE2	BRb2	T10	0.0126443769	D	b4	0.0262253743
39	TE3	BRc2	T10	0.0058236060	D	c6	0.0123302276

...	H	I	J	K
	60%-40% CVk	50%-50% CVk	40%-60% CVk	30%-70% CVk
	0.0105277910	0.0111747502	0.0118217094	0.0124686687
	0.0041533398	0.0051916748	0.0062300097	0.0072683447
	0.0176280051	0.0188094000	0.0199907949	0.0211721898
	0.0153285225	0.0150252604	0.0147219982	0.0144187361
	0.0182774803	0.0187825863	0.0192876924	0.0197927984
	0.0092386837	0.0096071526	0.0099756215	0.0103440904
	0.0073937815	0.0075369413	0.0076801011	0.0078232608
	0.0174531954	0.0178465172	0.0182398390	0.0186331608
	0.0175463183	0.0186245837	0.0197028491	0.0207811144
	0.0062597315	0.0075088707	0.0087580100	0.0100071492
	0.0117481913	0.0136927449	0.0156372985	0.0175818521
	0.0197003908	0.0210269214	0.0223534520	0.0236799826
	0.0120634542	0.0125251046	0.0129867550	0.0134484054
	0.0130673064	0.0136498872	0.0142324680	0.0148150487
	0.0099429137	0.0105539308	0.0111649478	0.0117759648
	0.0151447273	0.0156225949	0.0161004625	0.0165783301
	0.0118426743	0.0137308288	0.0156189833	0.0175071378
	0.0028554211	0.0035692764	0.0042831317	0.0049969870
	0.0095299500	0.0108071597	0.0120843695	0.0133615793
	0.0102067620	0.0127584525	0.0153101430	0.0178618335
	0.0071866099	0.0073485659	0.0075105219	0.0076724780
	0.0093306491	0.0105264543	0.0117222595	0.0129180647
	0.0058456910	0.0073071137	0.0087685364	0.0102299592
	0.0138263028	0.0147740735	0.0157218443	0.0166696150
	0.0127827543	0.0143380704	0.0158933865	0.0174487026
	0.0086228555	0.0082697644	0.0079166734	0.0075635823
	0.0180780992	0.0198682648	0.0216584303	0.0234485959
	0.0180767759	0.0194348756	0.0207929753	0.0221510751
	0.0084262547	0.0090769168	0.0097275790	0.0103782411

CVKE.WK1
Table 30.

A comparison of the various weights that could be used to calculate the CVk value was performed. The results are contained in the spreadsheet file ORDER-SA.WK1, which is shown in Table 31.

	A	B	C	D	E	F	G
1				60%-40%	50%-50%	40%-60%	30%-70%
2	TASK	D/E	ID	ORDER	ORDER	ORDER	ORDER
3	T6	D	b2	1	1	1	1
4	T4	D	b1	2	5	6	6
5	T10	D	a9	3	2	2	2
6	T10	D	b4	4	3	3	3
7	T3	D	a2	5	4	4	4
8	T5	D	a4	6	6	5	5
9	T5	D	a4	7	7	7	7
10	T4	D	a3	8	9	14	15
11	T7	E	a6	9	8	8	13
12	T9	D	a8	10	10	10	12
13	T6	D	d3	11	14	15	14
14	T10	E	a10	12	11	9	11
15	T6	D	c3	13	16	16	16
16	T7	D	b3	14	12	12	10
17	T6	E	a5	15	13	11	9
18	T1	D	a1	16	17	18	19
19	T8	E	a7	17	15	13	8
20	T7	E	a6	18	19	20	20
21	T7	D	d4	19	18	17	17
22	T8	D	d5	20	20	19	18
23	T4	D	c2	21	21	21	22
24	T10	E	a10	22	23	25	27
25	T10	D	c6	23	22	22	21
26	T4	E	d1	24	24	26	25
27	T8	D	c5	25	26	27	26
28	T5	D	d2	26	25	24	24
29	T8	D	d6	27	27	23	23
30	T2	D	c1	28	28	28	28
31	T7	E	c4	29	29	29	29

ORDER-SA.WK1
Table 31.

Using the same weights that were used in the actual project (40%-60%), the data pertinent was extracted from CVKE.WK1 to form the spreadsheet file CVKE-46.WK1 shown in Table 32.

	A	B	C	D	E	F	G	H
1	TEi	BRj	TASK	TVk	D/E	ID	DEk	40%-60% CVk
2	TE1	BRa1	T1	0.0079399541	D	a1	0.0144095463	0.0118217094
3	---	---	---		---	---		
4	TE3	BRc5	T2	0.0000000000	D	c1	0.0103833496	0.0062300097
5	---	---	---		---	---		
6	TE1	BRa4	T3	0.0129024254	D	a2	0.0247163746	0.0199907949
7	---	---	---		---	---		

8	TE1	BRa3	T4	0.0165415710	D	a3	0.0135089497	0.0147219982
9	TE2	BRb2	T4	0.0162570560	D	b1	0.0213081166	0.0192876924
10	TE3	BRc2	T4	0.0077648081	D	c2	0.0114494971	0.0099756215
11	TE4	BRd2	T4	0.0068211424	E	d1	0.0082527402	0.0076801011
12	---	---	---	---	---	---	---	---
13	TE1	BRa1	T5	0.0158799082	D	a4	0.0198131262	0.0182398390
14	TE1	BRa3	T5	0.0132332568	D	a4	0.0240159105	0.0197028491
15	TE4	BRd1	T5	0.0012631745	D	d2	0.0137545669	0.0087580100
16	---	---	---	---	---	---	---	---
17	TE1	BRa1	T6	0.0039699770	E	a5	0.0234155128	0.0156372985
18	TE2	BRb3	T6	0.0143942683	D	b2	0.0276595745	0.0223534520
19	TE3	BRc1	T6	0.0102168527	D	c3	0.0148333565	0.0129867550
20	TE4	BRd3	T6	0.0107369834	D	d3	0.0165627910	0.0142324680
21	---	---	---	---	---	---	---	---
22	TE1	BRa2	T7	0.0074988455	E	a6	0.0136090160	0.0111649478
23	TE1	BRa3	T7	0.0132332568	E	a6	0.0180119329	0.0161004625
24	TE2	BRb1	T7	0.0042900564	D	b3	0.0231716012	0.0156189833
25	TE3	BRc5	T7	0.0000000000	E	c4	0.0071385528	0.0042831317
26	TE4	BRd1	T7	0.0044211108	D	d4	0.0171932087	0.0120843695
27	---	---	---	---	---	---	---	---
28	TE1	BRa3	T8	0.0000000000	E	a7	0.0255169049	0.0153101430
29	TE3	BRc4	T8	0.0065387857	D	c5	0.0081583461	0.0075105219
30	TE4	BRd2	T8	0.0045474283	D	d5	0.0165054803	0.0117222595
31	TE4	BRd3	T8	0.0000000000	D	d6	0.0146142274	0.0087685364
32	---	---	---	---	---	---	---	---
33	TE1	BRa4	T9	0.0100352198	D	a8	0.0195129273	0.0157218443
34	---	---	---	---	---	---	---	---
35	TE1	BRa2	T10	0.0065614898	E	a10	0.0221146510	0.0158933865
36	TE1	BRa4	T10	0.0100352198	E	a10	0.0065043091	0.0079166734
37	TE1	BRa1	T10	0.0109174369	D	a9	0.0288190926	0.0216584303
38	TE2	BRb2	T10	0.0126443769	D	b4	0.0262253743	0.0207929753
39	TE3	BRc2	T10	0.0058236060	D	c6	0.0123302276	0.0097275790

CVKE-46.WK1
Table 32.

The CVk values contained in CVKE-46.WK1 were used to calculate the average CVk and summed CVk values in the spreadsheet file that ordered the consolidated capability issues. In the example the issues were consolidated by task, while in the actual study a number of issues might address the same task, but the issues were unique enough to stand alone or fall in different groups. The spreadsheet file CONS.WK1 constructed for the example is shown in Table 33.

	A	B	C	D	E
1	TASK	CON	D/E	ID	CVk
2	T1	CON 1	D	a1	0.0118217094
3	-----		----------		
4	T2	CON 2	D	c1	0.0062300097
5	-----		----------		
6	T3	CON 3	D	a2	0.0199907949
7	-----		----------		
8	T4	CON 4	D	a3	0.0147219982
9	T4	CON 4	D	b1	0.0192876924
10	T4	CON 4	D	c2	0.0099756215
11	-----		----------		
12	T4	CON 5	E	d1	0.0076801011
13	-----		----------		
14	T5	CON 6	D	a4	0.0182398390
15	T5	CON 6	D	a4	0.0197028491
16	T5	CON 6	D	d2	0.0087580100
17	-----		----------		
18	T6	CON 7	E	a5	0.0156372985
19	-----		----------		
20	T6	CON 8	D	b2	0.0223534520
21	T6	CON 8	D	c3	0.0129867550
22	T6	CON 8	D	d3	0.0142324680
23	-----		----------		
24	T7	CON 9	E	a6	0.0111649478
25	T7	CON 9	E	a6	0.0161004625
26	T7	CON 9	E	c4	0.0042831317
27	-----		----------		
28	T7	CON 10	D	b3	0.0156189833
29	T7	CON 10	D	d4	0.0120843695
30	-----		----------		
31	T8	CON 11	E	a7	0.0153101430
32	-----		----------		
33	T8	CON 12	D	c5	0.0075105219
34	T8	CON 12	D	d5	0.0117222595
35	T8	CON 12	D	d6	0.0087685364
36	-----		----------		
37	T9	CON 13	D	a8	0.0157218443
38	-----		----------		
39	T10	CON 14	E	a10	0.0158933865
40	T10	CON 14	E	a10	0.0079166734
41	-----		----------		
42	T10	CON 15	D	a9	0.0216584303
43	T10	CON 15	D	b4	0.0207929753
44	T10	CON 15	D	c6	0.0097275790

	F	G	H
1	AVG CVk	SUMMED CVk	OVERALL CVk
2	0.0118217094	0.0118217094	0.0118217094
3			
4	0.0062300097	0.0062300097	0.0062300097
5			
6	0.0199907949	0.0199907949	0.0199907949
7			
8	0.0146617707	0.0439853121	0.0293235414
9			
10			
11			
12	0.0076801011	0.0076801011	0.0076801011
13			
14	0.0155668993	0.046700698	0.0311337987
15			
16			
17			
18	0.0156372985	0.0156372985	0.0156372985
19			
20	0.016524225	0.049572675	0.0330484500
21			
22			
23			
24	0.0105161807	0.031548542	0.0210323613
25			
26			
28			
29	0.0138516764	0.0277033528	0.0207775146
30			
31	0.0153101430	0.0153101430	0.0153101430
32			
33	0.0093337726	0.0280013179	0.0186675452
34			
35			
36			
37	0.0157218443	0.0157218443	0.0157218443
38			
39	0.0119050299	0.0238100599	0.0178575449
40			
41			
42	0.0173929949	0.0521789847	0.0347859898
43			
44			

CONS.WK1
Table 33.

E. Ordered Issues.

The ordered list of consolidated capability issues for the example was produced by arranging the overall CVk in descending order. The ordered list that resulted is shown below.

ORDER	TASK	CON	D/E
1	T10	CON 15	D
2	T6	CON 8	D
3	T5	CON 6	D
4	T4	CON 4	D
5	T7	CON 9	E
6	T7	CON 10	D
7	T3	CON 3	D
8	T8	CON 12	D
9	T10	CON 14	E
10	T9	CON 13	D
11	T6	CON 7	E
12	T8	CON 11	E
13	T1	CON 1	D
14	T4	CON 5	E
15	T2	CON 2	D

F. Comments.

The example illustrates the analytical technique that developed the initial ordering of capability issues presented to the General Officer Steering Committee for review. It is not possible to replicate the process beyond the analytical portion of the prioritization process.

The spreadsheets built using the LOTUS 123 software are similar in format to the spreadsheets from the actual project, but due to

a smaller amount of data that could be contained in a single spreadsheet file, the number of files is noticeably smaller. In one situation the example mirrors an occurrence in the actual project. This is the case where a task was not selected as being essential to a particular battlefield requirement, but after analysis was determined to be an issue and therefore given a degradation/enhancement value. In the example, those DEk values are paired with a TVk value of zero. In the actual project, the study teams were asked to revisit their initial valuation of tasks and provide the missing valuations. As mentioned earlier, the number of issues submitted by the study teams far outnumbered the number of essential tasks identified, by a margin of more than two to one, while at the same time addressing only a few of the essential tasks originally valued. This has not been done in the example presented. The purpose of the example is to illustrate the analytical technique, not to mirror the actual inputs from the study teams.

IX. Summarization.

This project was initiated in April 1987 when the Commander of the Combined Arms Center and the Deputy Commander of the Training and Doctrine Command expressed concern with the methodology used to develop the Battlefield Development Plan for 1987. Investigation into alternative methodologies for the development of future BDPs began.

In order to resolve concerns with the lack of senior level involvement in the BDP process, the parochial views fostered by the mission area proponents, the loss of the corps perspective on battlefield capabilities, the inconsistency of earlier analysis efforts, and the failure to consider efficiencies as well as deficiencies, major adjustments in the process for building the Battlefield Development Plan for 1989 had to be instituted. The alternative methodology for developing BDP-89 began with the Close Combat Capability Analysis. The CCCA became the genesis of BDP-89.

An analytical methodology for producing an initial prioritized list of the capability issues identified during the CCCA was required. The Commander of the Combined Arms Combat Developments Activity was briefed in February 1988 on two methodologies. His decision was to use the multiple attribute decision tree

technique that I had proposed, and I was assigned the responsibility to develop the software to support the technique, as well as the responsibility to produce the analytically prioritized list of capability issues from the CCCA.

From March to July 1988, I developed the multiple attribute decision tree technique following the guidance from the senior leadership and wrote the macros required to construct LOTUS 123 spreadsheets that performed more than 6000 calculations and produced the initial list of prioritized capability issues for review by the General Officer Steering Committee.

In the beginning guidance was given that the Close Combat Capability Analysis prioritization methodology must be compatible with the approved analytic methodology in the CCCA study plan, validated within the current command and review structure, able to provide the initial prioritization of the capability issues, and, available in a timely manner. While not stated it was also required that the methodology be accomplished with the available resources, that is, money, men, and machines. It was these last two conditions that encouraged the CAC senior leadership to select the multiple attribute decision tree technique in March 1988 as the analytical technique to employ in the CCCA prioritization methodology. While more sophisticated analytical techniques were proposed, the time and analyst support required were not available. The multiple attribute decision tree technique while simpler was a valid technique for this exercise.

The list of prioritized CCCA capability issues finalized and approved in September 1988 attests to the validity of the analytical technique. There is a positive correlation between the final prioritized list of capability issues and the initial analytically prioritized list. Approximately 88% of the capability issues on the analytically ordered list were within 30% of their final placement by the GOSC. This is a respectable correlation. The multiple attribute decision tree technique was valid for its intended purpose of producing an initial ordering of issues to reduce the burden of dealing with unorganized information for the Council of Colonels and the General Officer Steering Committee in their efforts to establish the priority of the Army's capability issues. Decision trees properly implemented can give "alternate routes to confirm a decision ... confidence to make a decision ... understanding [of] what things impinge on ... decisions." [22] Whether this technique would be useful in other prioritization efforts is a question that requires further research.

The prioritized list of CCCA capability issues was distributed to all TRADOC schools and centers to use as the initial basis for development of the Battlefield Development Plan for 1989 (BDP-89). The BDP-89 prioritized list of 117 capability issues

[22] Richard S. Wurman, Information Anxiety. (New York: Doubleday), p. 79.

finalized and distributed for use in February 1989 also correlated positively with the analytically prioritized list of CCCA capability issues. Thus, the multiple attribute decision tree technique has been deemed valid enough by the TRADOC senior leadership to influence one of the Army's key budgetary documents.

The bottom line is that the multiple attribute decision tree technique did the job, and the job has been judged and found well done.

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APPENDIX A

Pairwise Comparison
and
Balanced Incomplete Block Design

The following is an excerpt from HQ TRADOC (ATCD-AM) Letter dated 18 January 1985 subject: Prioritization of Mission Area Deficiencies for BDP-85 - LOI.

(2) Deficiencies will be prioritized by each MA proponent. ... Experience has shown that the pairwise comparison methodology or the BIBD is simple to use and easily understood. An explanation of the standard pairwise comparison and the BIBD is provided at enclosure 2. ...

b. Phase II (25 Feb-10 May 85): General officer mail-outs for the purpose of integrating MA deficiencies into a strawman BDP-85 list.

(1) ... The general officers will be asked to pairwise compare a subset of deficiencies utilizing a comparison scale that will result in a cardinal ranking. ...

BALANCED INCOMPLETE BLOCK DESIGN

This year HQ TRADOC has tasked each mission area (MA) proponent to prioritize his specific mission area analysis (MAA) deficiencies rather than continue with the broader, more general Battlefield Development Plan (BDP) deficiencies as in the past. Because of the large number of specific MA deficiencies ... MA proponents will require a method to prioritize a greater number of deficiencies. The balanced incomplete block design (BIBD) will allow the MA proponent to subdivide the total number of specific MA deficiencies into smaller subsets for prioritization. This will reduce the burden placed on each individual and allow for a greater number of specific MA deficiencies to be prioritized within each of the mission areas. This decrease in burden is demonstrated in the following table where the number of paired comparisons geometrically increases with the number of deficiencies.

Table I

No. of MA Deficiencies	No. of Paired Comparisons Required
20	190
25	300
30	435
35	595
40	780
45	990
50	1225

Each MA proponent will have to make a judgment as to what is an acceptable number of paired comparisons for each individual. Table II demonstrates how beneficial it would be if 60

deficiencies were subdivided into three subsets of 20 deficiencies each.

Table II

No. of MA Deficiencies	No. of Paired Comparisons Required	
60	1,770	
3 subsets of 20 deficiencies	190	Total of 570

If the number of specific MA deficiencies are small in number (30 or less), then each individual should evaluate the complete set. If the number is larger (greater than 30), each MA expert should evaluate a selected subset of the total number of specific MA deficiencies within the respective MA. ... each specific MA deficiency has to be given an equal opportunity of becoming the top or bottom ranked deficiency. In order for this to happen each specific MA deficiency must appear the same number of times. Also the deficiencies an equal number of time during the evaluation.

The BIBD has these characteristics; every pair of deficiencies occurs together the same number of times, allowing each deficiency an equal chance of being the top ranked deficiency in the set of specific MA deficiencies. The actual design will depend upon the number of specific deficiencies, the number of MA experts (individuals), and the degree of discrimination required to gain consensus. Some degree of replication will be required. Hence, each pair of deficiencies should be evaluated by a number of MA experts so that adequate representation is placed on each specific deficiency. The following is the mathematical formulation for a BIBD (see references for more detail). The following notation is used:

N = Number of total observations
t = Number of deficiencies
r = Number of replications of each deficiency
b = Number of mission area experts (evaluators)
k = Number of deficiencies evaluated by each evaluator
λ = Number of times two specific deficiencies are evaluated

The following relationships must be satisfied:

$$r(k-1)/(t-1) = N(k-1)/t(t-1) = \lambda \qquad (1)$$

$$N = tr = bk \qquad (2)$$

Not all BIBD are symmetrical. A necessary and sufficient condition for a symmetrical design is that b = t, i.e., the number of evaluators must equal the number of deficiencies;

consequently, k = r. In order to utilize these relationships (1 and 2) a number of these variables (t, r, b, k and λ) must first be fixed before solving for the others. An example is given where we first subdivide the total number of deficiencies and then apply the BIBD to the subsets. If one subdivided the total, then a control MA deficiency is required in each BIBD. This control MA deficiency is required to integrate the individual subsets into one list. This example has a small number of deficiencies in order to communicate the basic idea. Suppose 28 specific MA deficiencies needed to be prioritized by the MA proponent this year. This would require each expert to perform 378 paired comparisons in order to prioritize all 28 deficiencies. On the other hand, if we utilize the BIBD and subdivide the 28 deficiencies into four subsets of equal size, seven deficiencies plus a control deficiency for a total of eight, then each MA expert would be required to evaluate four sets of four deficiencies each. (See figure 1, a design to evaluate eight specific deficiencies.) This would require a total of 24 paired comparisons as compared to 378, a major reduction in the required level of effort.

BALANCED INCOMPLETE BLOCK DESIGN

MA Experts (14)	Specific Mission Area Deficiencies 1	2	3	4	5	6	7	8
A	X	X	X	X				
B	X	X					X	X
C	X		X			X		X
D	X			X		X	X	
E					X	X	X	X
F			X	X	X	X		
G		X		X	X		X	
H		X	X		X		X	
I	X	X			X	X		
J	X		X		X		X	
K	X			X	X			X
L			X	X			X	X
M		X		X		X		X
N		X	X			X	X	

t = 8, k = 4, r = 7, b = 14, N = 56, λ = 3

Figure 1

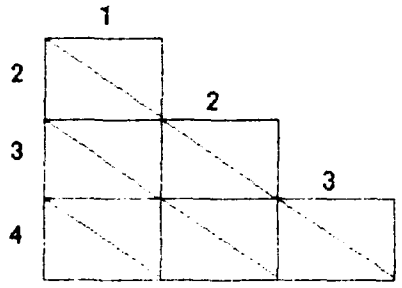
This design is not symmetrical. That is, the number of deficiencies is not equal to the number of evaluators (experts). In this case, one deficiency, picked at random is placed in each of the four subsets of deficiencies. This control (standard) deficiency is used to integrate/gauge the four subsets of eight

deficiencies into one cardinally ranked (prioritized) list. In the above BIBD each deficiency is evaluated seven times by the 14 evaluators (experts) and each pair appears three times, e.g., deficiencies 1 and 2 occur in A, B and I half-matrix, and deficiencies 1 and 3 occur in A, C and J half-matrix, and so on. Hence, this BIBD satisfies the requirement that every pair occurs together the same number of times (λ =3). Once the BIBD is chosen, a half-matrix (figure 2) is prepared for each of the evaluators (MA expert) tasked to pairwise compare the specific MA deficiencies according to the common scale in table III.

PAIRWISE COMPARISON HALF-MATRIX FROM BIBD

Mission Area Expert A

Deficiencies



Mission Area Expert B

Deficiencies

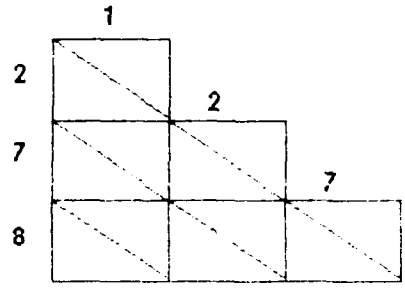


Figure 2

TABLE III

Evaluation Scale

Definition	Intensity of Importance	Explanation
A. Equal importance	1	Two deficiencies contribute equally.
C. Weak importance of one over another	3	Experience and judgment slightly favor one deficiency over another.
E. Strong importance of one over another	5	Experience and judgment strongly favor one deficiency over another.

Evaluation Scale

Definition	Intensity of Importance	Explanation
G. Very strong or demonstrated importance	7	A deficiency is favored very strongly over another; its dominance demonstrated in practice.

B, D, F. Intermediate values between adjacent scale values.

This year pairwise comparison will be modified by employing the eigenvalue/eigenvector methodology developed and used extensively in Design of Experiments/Analysis of Variance (AOV). Two advantages of employing the eigenvalue/eigenvector methodology is the development of a cardinal scale associated with each deficiency and the consistency test for monitoring individual judgment. This does not mean that consistency is everything. On the other hand, the more a person knows, the more consistent he or she is likely to be. Also, a cardinal scale allows deficiencies to be removed (deleted and rolled up) without changing or adjusting the associated cardinal value of other deficiencies.

In filling out the half-matrix, mission area expert A must use the recommended scale (table III). He should start with MA deficiency 1 vs 2 in the upper left-hand call of his half-matrix. In this case, MA expert A strongly prefers deficiency 2 over deficiency 1. Therefore, placing an E in the lower half-cell closes [sic] to the number 2 for deficiency 2.

PAIRED COMPARISON

Mission Area Expert A

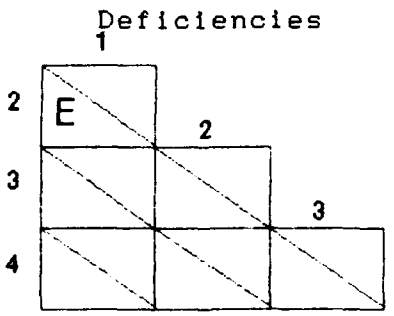


Figure 3

Next, MA expert A pairwise compares MA deficiency 1 vs 3 in the cell (3, 1), row 3 and column 1. In this case, MA expert A makes a judgment of weakly preferring deficiency 3 over deficiency 1. Therefore, placing a C in the lower half-cell closes [sic] to the number 3 for deficiency 3. The final pairwise comparison example is comparing MA deficiency 1 vs 4. In this case, MA expert A judges that deficiency 1 is equal to deficiency 4. Therefore, placing an A in the upper half-cell closes [sic] to the number 1 for deficiency 1. The placement of the letter (A, B, C, D, E, F and G) in either the upper or lower half-cell of the half-matrix indicates which deficiency is the preferred deficiency of the two.

The completed half-matrix is shown in figure 4.

PAIRED COMPARISON

Mission Area Expert A

Deficiencies

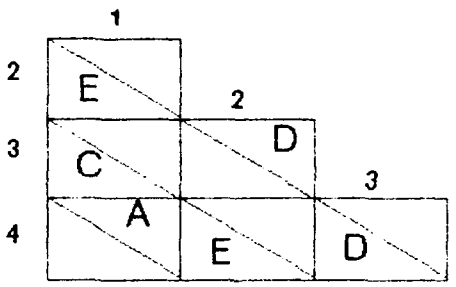


Figure 4

This completed half-matrix is now translated into the positive reciprocal matrix with the aid of table IV below.

TABLE IV

Letter	Numerical Scale (Intensity)
A	1
B	2
C	3
D	4
E	5
F	6
G	7

The resulting matrix for MA expert A is shown below:

POSITIVE RECIPROCAL MATRIX

Deficiencies	1	2	3	4
1	1	1/5	1/3	1
2	5	1	4	1/5
3	3	1/4	1	1/4
4	1	5	4	1

This positive reciprocal matrix has the properties that all diagonal elements, aij = 1, are equal to 1, and all other elements aij = 0, are non-negative.

The characteristic equation of this positive reciprocal matrix is:

$$A = \begin{bmatrix} 1 & 1/5 & 1/3 & 1 \\ 5 & 1 & 4 & 1/5 \\ 3 & 1/4 & 1 & 1/4 \\ 1 & 5 & 4 & 1 \end{bmatrix} \qquad \lambda I = \begin{bmatrix} \lambda & 0 & 0 & 0 \\ 0 & \lambda & 0 & 0 \\ 0 & 0 & \lambda & 0 \\ 0 & 0 & 0 & \lambda \end{bmatrix}$$

$$(A - \lambda I) = \begin{bmatrix} 1-\lambda & 1/5 & 1/3 & 1 \\ 5 & 1-\lambda & 4 & 1/5 \\ 3 & 1/4 & 1-\lambda & 1/4 \\ 1 & 5 & 4 & 1-\lambda \end{bmatrix} = 0$$

This characteristic equation is a fourth degree polynomial with multiple roots. We are only interested in the maximum root (maximum eigenvalue) to obtain the corresponding eigenvector values (cardinal rankings). The corresponding eigenvector from the largest to the smallest establishes the priority of the specific MA deficiencies.

$$\begin{bmatrix} 1 & 1/5 & 1/3 & 1 \\ 5 & 1 & 4 & 1/5 \\ 3 & 1/4 & 1 & 1/4 \\ 1 & 5 & 4 & 1 \end{bmatrix} \times \begin{bmatrix} w1 \\ w2 \\ w3 \\ w4 \end{bmatrix} = \lambda_{max} \begin{bmatrix} w1 \\ w2 \\ w3 \\ w4 \end{bmatrix}$$

We have four equations and four unknowns (w1, w2, w3, w4). The eigenvalues ( ), one of the roots of polynomial, can be obtained by standard numerical methods from canned computer programs.

In this case the exact solution is:

POSITIVE RECIPROCAL MATRIX

Deficiencies	1	2	3	4	Eigenvector (w)
1	1	1/5	1/3	1	0.127
2	5	1	4	1/5	0.281
3	3	1/4	1	1/4	0.120
4	1	5	4	1	0.463

λ_{max} = 5.42, C.I. = 0.47*, C.R. = 0.52**

*C.I. - Consistency Index = $(\lambda_{max} - n)/(n-1)$;
$(5.42 - 4)/(4-1) = 0.47$

**C.R. - Consistency Ratio = C.I./R.I. where R.I. is the random index and C.I. is the consistency index.
C.R. = (0.47/0.90) = 0.52.

The consistency index (C.I.) is a measure of consistency in the judgments made by each expert in developing the positive reciprocal matrix. In general, if this number is less than 0.1, the judgments are satisfactory (consistent). The smaller the index the better is the consistency.

On the other hand, the consistency ratio (C.R.) is a measure of consistency when a random degree of expected inconsistency (noise) is considered due to the size of the matrix. Oak Ridge National Laboratory and the Wharton School, University of Pennsylvania, have generated a random index (R.I.) to consider this effect. A consistency ratio of 0.10 or less is acceptable.

In this example the cardinal priority of deficiencies 1, 2, 3, and 4 are (0.13, 0.28, 0.12, 0.46). By filling in the BIBD in figure 1 with these eigenvectors values and totalling the columns, a prioritized list of specific MA deficiencies is produced. If you wish to average the columns, it is your option.

Once the cardinal values (priority) of the four subsets of eight deficiencies each are completed, the priority of all 28 deficiencies can be established by lining up the one controlled deficiency that appears in each BIBD. One should pick the priority list where the control deficiency appears as close to the center as possible. Then, for each merge (three in all for this example) the following transformation is used:

MERGING FORMULATION

(new value for base list) = α(const.)*(value from merging list)
where

$$\alpha = \frac{\text{(control cardinal value from base list)}}{\text{(control cardinal value from merging list)}}$$

A demonstration of merging list 2 into list 1 is as follows:

List 1 (Deficiency)	Cardinal Value (Eigenvector)	List 2 (Deficiency)	Cardinal Value (Eigenvector)
6	(0.220)	11	(0.220)
3	(0.187)	9	(0.165)
2	(0.140)	5	(0.140)*
8	(0.128)	15	(0.135)
5	(0.125)*	14	(0.120)
1	(0.100)	10	(0.100)
4	(0.080)	12	(0.070)
7	(0.020)	13	(0.050)
Total	1.00		1.00

The * is the controlled deficiency common to both subsets. The merging transformation is:

(merged cardinal value) = α*(old cardinal value):

where α = (0.125)/(0.140)

The actual merge is shown below:

α = 0.8928 (constant)

List 2	Transformed Value	Merged List of List 1 & 2
11 (0.220)	(0.196)	6 (0.220)
		11 (0.220)
		3 (0.187)
9 (0.165)	(0.147)	9 (0.147)
		2 (0.140)
		8 (0.128)
*5 (0.140)	(0.125)	*5 (0.125)
15 (0.135)	(0.121)	15 (0.121)
14 (0.120)	(0.107)	14 (0.107)
		1 (0.100)
10 (0.100)	(0.089)	10 (0.089)
		4 (0.080)
12 (0.070)	(0.062)	12 (0.062)
13 (0.050)	(0.045)	13 (0.045)
		7 (0.020)

By continuing this merging process for subset 3 and subset 4 a total cardinal priority list is established.

In the absence of a computer program to solve the positive reciprocal matrix, eigenvalue and eigenvector, an estimate of the eigenvector can be obtained by using the following method. The method involves dividing each column element by the sum of that column, then summing the resulting rows and dividing by the number of elements in the rows. This process is called "averaging over the normalized column."

- Sum the columns and normalized matrix.

					Normalized Matrix			
Deficiencies	1	2	3	4	1	2	3	4
1	1	1/5	1/3	1	0.10	0.03	0.04	0.41
2	5	1	4	1/5	0.50	0.16	0.43	0.08
3	3	1/4	1	1/4	0.30	0.04	0.11	0.10
4	1	5	4	1	0.10	0.78	0.43	0.41
	10.0	6.45	9.33	2.45				

- Sum rows and divided by number of elements.

Row	Sum	Divide by Number of Elements	Exact Solution
1	0.58	0.14	0.13
2	1.17	0.29	0.28
3	0.55	0.13	0.12
4	1.72	0.43	0.46

This method gives a good estimate of the actual solution and is consistent. We can also estimate the consistency index (C.I.) by multiplying the original matrix by the estimated solution (0.14, 0.29, 0.13, 0.43), then dividing by the solution vector (eigenvector), and take the average.

$$\begin{bmatrix} 1 & 1/5 & 1/3 & 1 \\ 5 & 1 & 4 & 1/5 \\ 3 & 1/4 & 1 & 1/4 \\ 1 & 5 & 4 & 1 \end{bmatrix} \times \begin{bmatrix} .14 \\ .29 \\ .13 \\ .43 \end{bmatrix} = \begin{bmatrix} 0.67 \\ 1.59 \\ 0.73 \\ 2.54 \end{bmatrix}$$

$0.67/.14 = 4.78$

$1.59/.29 = 5.48$

$0.73/.13 = 5.62$

$2.54/.43 = 5.91$

Sum 21.79

Average 5.44

λ_{max} 5.44

Consistency Index C.I. = (5.44 - 4)/3 = 0.48

Finally, the eigenvalue/eigenvector approach to pairwise comparisons provides a method for establishing a numerical (cardinal) scale, particularly in the areas where measurements and quantitative comparisons do not exist. The consistency index and consistency ratio enables one to monitor judgments during the priority process. The BIBD should be utilized for those situations where the number of paired comparison overburdens the MA experts (evaluators). A more valid priority list will results [sic] from reducing the number of paired comparisons to a reasonable level than to overburden the experts and introduce noise into the evaluation. The BIBD plus the eigenvalue/eigenvector approach will provide TRADOC with the necssary [sic] data to integrate a priority deficiency list.

References:

1. Davies, O. L., The Design and Analysis of Industrial Experiments, Hofner Publishing Company, NY. 1954-1971

2. Cochran, W. C., and Cox, G. M., Experimental Design, Wiley & Son (New York, 1950-1957)

3. Yates, F., Incomplete Randomised Blocks, Annals of Eugenics, 7 (1936), 1980

4. Saaty, T. L., The Analytic Hierarchy Process, McGraw-Hill, 1980.

APPENDIX B

Selected Briefing Slides
from
Close Combat Capability Analysis
Information Briefing
16 March 1988
Fort Leavenworth, Kansas

CLOSE COMBAT CAPABILITY ANALYSIS
(CCCA)

INFORMATION BRIEFING
TRADOC COMMANDER

16 MARCH 1988

CCCA STUDY OVERVIEW

OPERATING PRINCIPLES

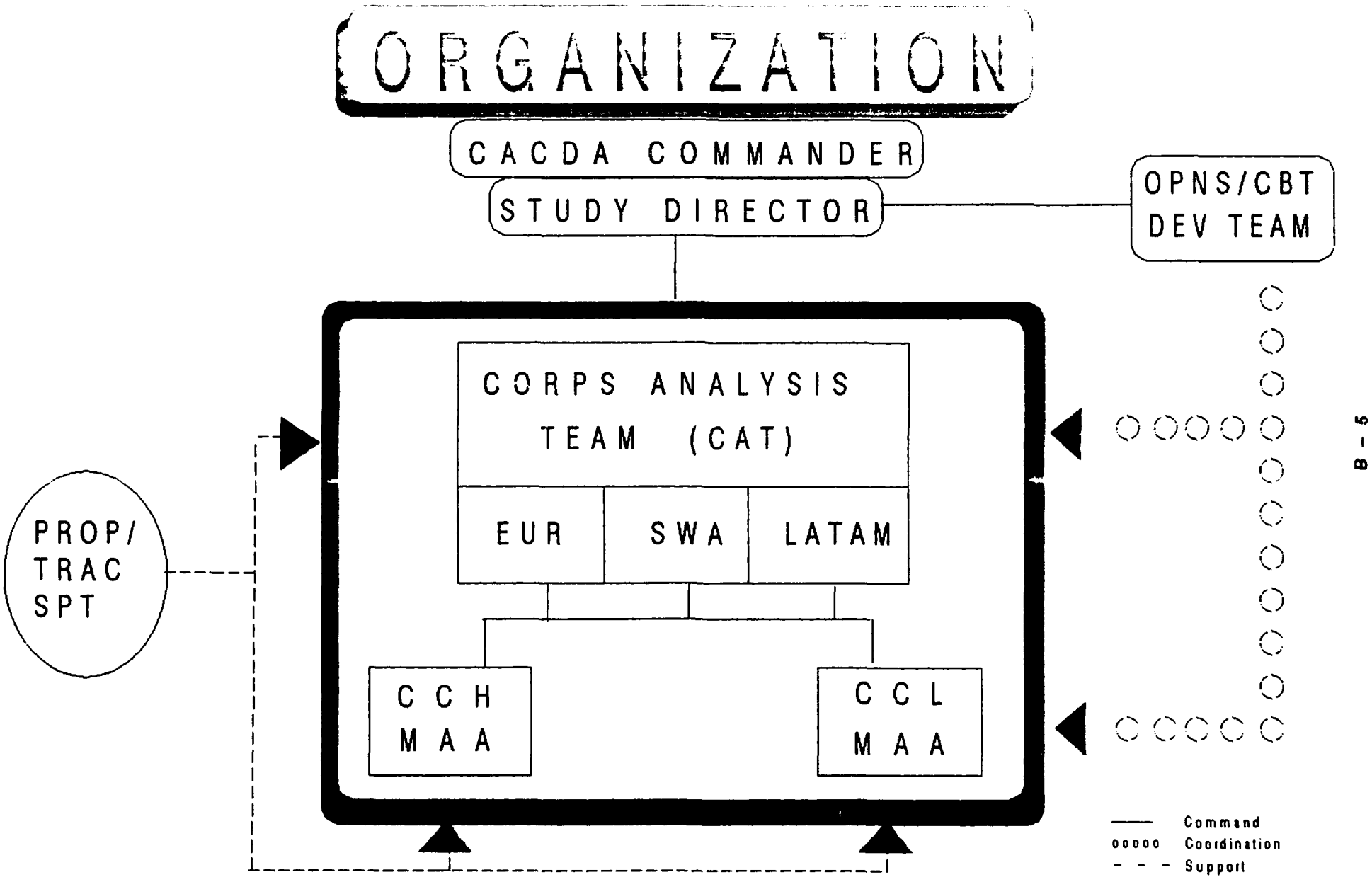
- CCH and CCL MAAs conducted in FY 88
- CACDA is responsible agent
- TRADOC schools/centers participate
- Threat based concepts:
  - Threat heavy forces
  - Threat light forces including special operations
- Consider both a developed and contingency corps

TRADOC: 10 Aug 87

DECISION

- CACDA Cdr will direct close combat capabilities analysis (CCCA) at CAC, USAARMC, and USAIC.
- Three scenarios will be examined: Europe, Southwest Asia, and Latin America.
- Corps/Division analysis conducted at CAC.
- Subordinate brigade/battalion analysis by CCH/CCL complements CAC effort and produces proponent MAAs.
- Results reviewed by senior Army Leadership

TRADOC Cdr: 24 Sep 87


ORGANIZATION
CACDA COMMANDER
STUDY DIRECTOR
OPNS/CBT DEV TEAM
CORPS ANALYSIS TEAM (CAT)
EUR
SWA
LATAM
CCH MAA
CCL MAA
PROP/ TRAC SPT
Command
Coordination
Support

RESOURCES

- PERSONNEL (Full Time)

	Military	Civilian
FLVN (TRAC FLVN)	18 (4)	23 (11)
Knox	17	5
Benning	7	1
Totals	42 (4)	29 (11)

  - Proponent representatives at each study site
  - Modeling/Gaming support at WSMR, Knox, Benning, Rucker
  - Deployment analysis at LOGC (Trans CTR)
  - Nuclear excursion by DNA

- FUNDING: $736K allotted for FY 88 TDY

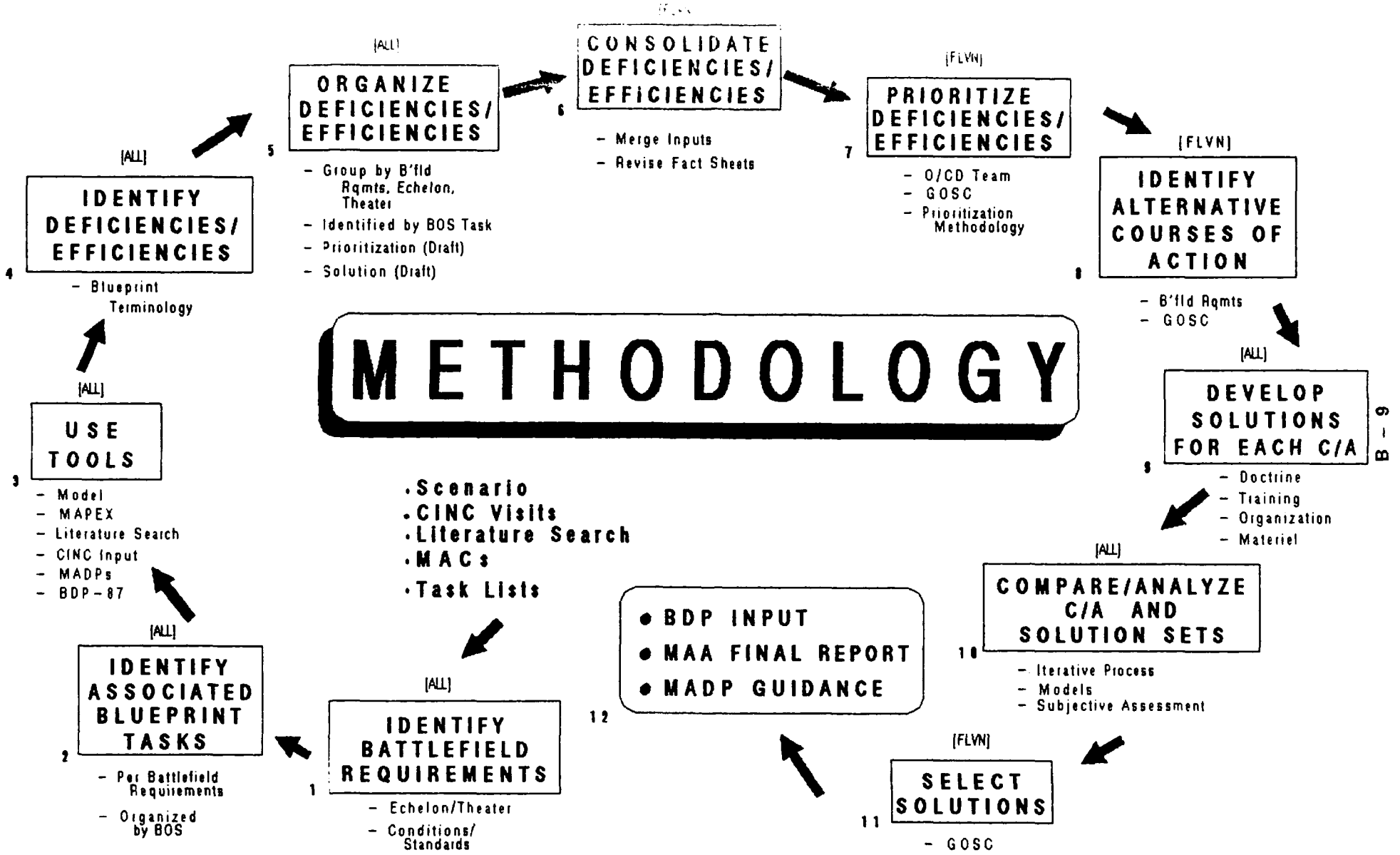
ROLES

- TRADOC DCSCD: Study Sponsor
- CACDA: Study Agency
  - Manage study resources
  - Coordinate proponent support
  - Conduct corps level analysis
  - Prepare final study report
- USAARMC/USAIC: Deputy Study Agencies
  - Conduct Bde/Bn level analysis
  - Prepare Close Combat (Heavy/Light) MAA as appendix to final report

ROLES CONTD

- PROPONENTS: Study Contributors
  - Provide input/support to study effort
  - Examine issues/corrective action strategies
  - Develop MAA update (MADP) based on participation in study effort

- TRAC: Analytic Support Agency
  - Develop/coordinate/obtain approval of study plan
  - Develop/finalize study scenarios; prepare models
  - Conduct simulations/gaming
  - Assist analysis and study report preparation


METHODOLOGY
1 IDENTIFY BATTLEFIELD REQUIREMENTS
[ALL]
- Echelon/Theater
- Conditions/ Standards
2 IDENTIFY ASSOCIATED BLUEPRINT TASKS
[ALL]
- Per Battlefield Requirements
- Organized by BOS
3 USE TOOLS
[ALL]
- Model
- MAPEX
- Literature Search
- CINC Input
- MADPs
- BDP-87
4 IDENTIFY DEFICIENCIES/ EFFICIENCIES
[ALL]
- Blueprint Terminology
5 ORGANIZE DEFICIENCIES/ EFFICIENCIES
[ALL]
- Group by B'fld Rqmts, Echelon, Theater
- Identified by BOS Task
- Prioritization (Draft)
- Solution (Draft)
6 CONSOLIDATE DEFICIENCIES/ EFFICIENCIES
- Merge Inputs
- Revise Fact Sheets
7 PRIORITIZE DEFICIENCIES/ EFFICIENCIES
[FLVN]
- O/CD Team
- GOSC
- Prioritization Methodology
8 IDENTIFY ALTERNATIVE COURSES OF ACTION
[FLVN]
- B'fld Rqmts
- GOSC
9 DEVELOP SOLUTIONS FOR EACH C/A
[ALL]
- Doctrine
- Training
- Organization
- Materiel
10 COMPARE/ANALYZE C/A AND SOLUTION SETS
[ALL]
- Iterative Process
- Models
- Subjective Assessment
11 SELECT SOLUTIONS
[FLVN]
- GOSC
12
• BDP INPUT
• MAA FINAL REPORT
• MADP GUIDANCE
• Scenario
• CINC Visits
• Literature Search
• MACs
• Task Lists
B-9

MILESTONES

- Initiated study — OCT 87
- Task analysis — OCT 87 - MAR 88
  - Determine battlefield requirements
  - Associate Blueprint tasks
- Identify capability issues — NOV 87 - MAY 88
  - Gaming/MAPEX
  - BDP/MADP
  - CINC input, Lessons Learned, other studies
- Prioritization of capability issues — JUN - JUL 88
  - Merge study inputs
  - Prioritize issues (GOSC)
  - Prepare initial BDP input

MILESTONES CONTD

- Develop course of action — JUN - OCT 88
  - Alternative courses
  - Solution sets for each course of action
- Select solution — NOV 88
  - GOSC
- Senior level review — DEC 88
- Final study report — NOV 88 - JAN 89

APPENDIX C

Essential Task List

TASK NUMBER	TASK DESCRIPTION
1.1.1 A	Position/reposition forces
1.1.1.1 A	Move on or under the surface
1.1.1.1.1	Move while mounted
1.1.1.1.2	Move while dismounted
1.1.1.2	Move through air
1.1.2	Negotiate Terrain
1.1.3	Navigate
1.1.4	Perform battlefield circulation control (BCC)
1.2.1 A	Employ direct fire
1.2.1.1.1	Select target
1.2.1.1.2	Select fire system
1.2.1.2	Attack targets
1.2.2 A	Conduct close combat
1.3.1	Control terrain through fire or fire potential
1.3.2	Occupy terrain
2.1.1	Select target to attack
2.1.2.1	Determine system capability
2.1.2.2	Determine system availability
2.1.2.3	Select system
2.1.3 A	Develop order to fire
2.2.1.1	Conduct surface attack
2.2.1.2	Adjust/illuminate Fire Support
2.2.1.3	Request Air-to-ground Attack
2.2.2.1.1	Employ incapacitating agents
2.2.2.1.2	Conduct battlrfield psychological activities
2.2.2.2.1	Conduct jamming
2.2.2.2.2 A	Counter target acquisition
3.1.1	Select target to attack
3.1.2.1	Determine system capability
3.1.2.2	Determine system availability
3.1.2.3	Select system
3.1.3 A	Develop order to fire
3.2.1.1	Employ air-to-air weapons
3.2.1.2.1	Employ air defense artillery
3.2.1.2.2	Employ other unit fires
3.2.2	Ccnduct nonlethal attack
3.3	Deny airspace
4.1.1 A	Communicate information
4.1.1.1	Receive and transmit mission
4.1.1.2	Receive and transmit enemy information
4.1.1.3	Receive and transmit terrain and weather info
4.1.1.4	Receive and transmit friendly troop information
4.1.2	Manage means of communicating information
4.1.3.1 A	Store information
4.1.3.2	Display information
4.1.3.3	Publish and reproduce information
4.1.3.4	Distribute informat' n

TASK NUMBER	TASK DESCRIPTION
4.2.1	Review current situation
4.2.1.1 A	Analyze mission
4.2.1.2 A	Fuse information
4.2.1.3 A	Evaluate incoming information
4.2.2	Project future requirements
4.2.3	Decide on need for action or change
4.3.1	Issue planning guidance
4.3.2	Develop courses of action
4.3.3	Analyze courses of action
4.3.4	Compare courses of action
4.3.5	Select or modify course of action
4.4.1.1	Develop and complete plans oe orders
4.4.1.2	Coordinate support
4.4.1.3 A	Approve orders
4.4.2	Issue orders
4.4.3	Provide command presence
5.1.1.1	Collect threat information
5.1.1.2	Collect physical environment information
5.1.1.3	Collect info on social/political/economic environ
5.1.2 A	Collect target information
5.1.2.1	Search for targets
5.1.2.2	Detect targets
5.1.2.3	Locate targets
5.1.2.4	Identify targets
5.1.2.5	Conduct post-attack target damage assessment
5.2.1.1 A	Review holdings
5.2.1.2 A	Consider enemy doctrine
5.2.1.3	Develop enemy intentions
5.2.2.1 A	Review holdings
5.2.2.2 A	Consider status
5.2.2.3	Develop impacts
5.2.3	Evaluate social/political/economic environment
5.3.1	Prepare reports on target development
5.3.2	Prepare reports on enemy intentions
5.3.3	Prepare reports on the battlefield area
5.3.4	Prepare reports on enemy situation
6.1.1.1.1	Breach minefields
6.1.1.1.2	Breach all other obstacles
6.1.1.2	Reduce/clear obstacles
6.1.1.3	Cross gaps
6.1.1.4 A	Report
6.1.2.1	Construct/repair combat roads and trails
6.1.2.2	Construct/repair forward airfields and landing fld
6.2.1 A	Secure/select location of reinforcing obstacles
6.2.2.1	Emplace mines
6.2.2.2	Prepare/emplace constructed obstacles
6.2.2.3	Emplace demolition obstacles

TASK NUMBER	TASK DESCRIPTION
6.2.3 A	Mark obstacles
6.2.4	Detonate mines/explosives
6.3.1.1 A	Protect individuals and systems
6.3.1.1.1	Employ electronic counter-countermeasures (ECCM)
6.3.1.1.2	Prepare fighting positions
6.3.1.1.3	Prepare protective positions
6.3.1.1.4	Use protective equipment
6.3.1.2.1	Decontaminate personnel and systems
6.3.1.2.2	Provide explosive ordnance disposal (EOD) support
6.3.2 A	Employ operations security
6.3.2.1	Employ signal security (SIGSEC)
6.3.2.1.1.1 A	Employ physical security measures
6.3.2.1.1.2 A	Maintain emission security
6.3.2.1.2 A	Maintain electronic security
6.3.2.2.1	Employ camouflage
6.3.2.2.2	Employ smoke/obscurants
6.3.3.1	Employ physical deceptionEmploy physical deception
6.3.3.2	Employ electronic deception
6.3.3.2.1 A	Employ imitative electronic deception
6.3.3.2.2 A	Employ simulative electronic deception
6.3.3.2.3 A	Employ manipulative electronic deception
6.3.4	Provide security
7.1 A	Arm
7.2 A	Fuel
7.3.2.1	Perform preventive maintenance
7.3.2.2	Recover materiel
7.3.2.3	Diagnose malfunctions
7.3.2.4 A	Substitute parts/equipment
7.3.2.5 A	Exchange parts/equipment
7.3.2.6	Repair equipment
7.3.2.7	Return repaired equipment
7.4.2.1	Clothing exchange and bath
7.4.2.2	Graves registration
7.4.2.3 A	Salvage
7.4.2.4	Laundry and renovation
7.4.2.5 A	Bakery
7.4.2.6	Feeding
7.4.3.1.1	Provide strength management
7.4.3.1.2	Conduct replacement operations
7.4.3.1.3 A	Perform casualty reporting operations
7.4.3.1.4	Provide personnel management support
7.4.3.1.5 A	Conduct postal operations
7.4.3.2	Provide finance services
7.4.3.2.3 A	Perform disbursing services
7.4.3.4	Perform chaplaincy activities
7.4.3.4.1 A	Provide unit ministry
7.4.3.5	Provide public affairs services

TASK NUMBER	TASK DESCRIPTION
7.4.3.5.1 A	Provide command information
7.4.3.6	Provide legal services support
7.4.3.6.2 A	Administer criminal law
7.4.4.1	Provide medical treatment
7.4.4.2	Evacuate casualties
7.4.4.3	Provide preventative medicine
7.5.1.1.2	Unload
7.5.1.1.3	Load
7.5.1.1.4	Provide terminal services
7.5.1.2 A	Move/evacuate cargo, equipment, and personnel
7.5.1.2.1	Move by surface (cargo, equipment, and personnel)
7.5.1.2.2	Move by air (cargo, equipment, and personnel)
7.5.2.1.1 A	Request Classes I, II, IV, VI, VII, IX, X
7.5.2.1.2 A	Request Water
7.5.2.1.3 A	Request Munitions (Class V)
7.5.2.1.4 A	Request Fuel (Class III)
7.5.2.1.5 A	Request Medical (Class VIII)
7.5.2.1.6 A	Request Maps
7.5.2.2	Receive supplies
7.5.2.2.1 A	Receive Classes I, II, IV, VI, VII, IX, X
7.5.2.2.2 A	Receive Water
7.5.2.2.3 A	Receive Munitions (Class V)
7.5.2.2.4 A	Receive Fuel (Class III)
7.5.2.2.5 A	Receive Medical (Class VIII)
7.5.2.2.6 A	Receive Maps
7.5.2.3 A	Produce supplies
7.5.2.3.2 A	Produce Water
7.5.2.4	Procure supplies
7.5.2.5.1 A	Procure Classes I, II, IV, VI, VII, IX, X
7.5.2.5.2 A	Procure Water
7.5.2.5.3 A	Procure Munitions (Class V)
7.5.2.5.4 A	Procure Fuel (Class III)
7.5.2.5.5 A	Procure Medical (Class VIII)
7.5.2.5.6 A	Procure Maps
7.5.2.6	Protect supplies
7.5.2.6.1 A	Protect Classes I, II, IV, VI, VII, IX, X
7.5.2.6.2 A	Protect Water
7.5.2.6.3 A	Protect Munitions (Class V)
7.5.2.6.4 A	Protect Fuel (Class III)
7.5.2.6.5 A	Protect Medical (Class VIII)
7.5.2.6.6 A	Protect Maps
7.5.2.7.1 A	Relocate Classes I, II, IV, VI, VII, IX, X
7.5.2.7.2 A	Relocate Water
7.5.2.7.3 A	Relocate Munitions (Class V)
7.5.2.7.4 A	Relocate Fuel (Class III)
7.5.2.7.5 A	Relocate Medical (Class VIII)
7.5.2.7.6 A	Relocate Maps

TASK NUMBER	TASK DESCRIPTION
7.5.2.8	Issue supplies
7.5.2.8.1 A	Issue Classes I, II, IV, VI, VII, IX, X
7.5.2.8.2 A	Issue Water
7.5.2.8.3 A	Issue Munitions (Class V)
7.5.2.8.4 A	Issue Fuel (Class III)
7.5.2.8.5 A	Issue Medical (Class VIII)
7.5.2.8.6 A	Issue Maps
7.6.1	Rear area restoration
7.6.2	LOC sustainment
7.6.3	Provide engineer construction support
7.6.4	Provide engineer construction material
7.7.1	Perform EPW operations
7.7.2	Conduct law and order operations

NOTE: A following a task number indicates a task not in the population of tasks from the Blueprint of the Battlefield proposed for consideration in the selection of essential tasks. These tasks were added to the list by the three study teams.

APPENDIX D

Analytically Ordered Task List
from
Part I Inputs

ORDER	TASK	
1	5.1.2 A	Collect target information
2	4.1.1 A	Communicate information
3	7.5.1.2.1	Move by surface (cargo, equipment, and personnel)
4	6.3.2 A	Employ operations security
5	1.2.1 A	Employ direct fire
6	7.5.1.2.2	Move by air (cargo, equipment, and personnel)
7	7.5.2.6	Protect supplies
8	6.3.1.1 A	Protect individuals and systems
9	2.2.1.1	Conduct surface attack
10	1.1.1.1 A	Move on or under the surface
11	7.5.1.1.4	Provide terminal services
12	1.1.1 A	Position/reposition forces
13	5.1.1.1	Collect threat information
14	5.1.2.4	Identify targets
15	5.1.2.3	Locate targets
16	1.2.1.2	Attack targets
17	5.1.2.2	Detect targets
18	3.2.1.2.1	Employ air defense artillery
19	7.6.2	LOC sustainment
20	4.1.1.1	Receive and transmit mission
21	4.4.1.2	Coordinate support
22	2.2.1.3	Request Air-to-ground Attack
23	7.5.2.8	Issue supplies
24	4.2.1	Review current situation
25	4.1.1.2	Receive and transmit enemy information
26	1.3.1	Control terrain through fire or fire potential
27	7.1 A	Arm
28	6.3.2.1	Employ signal security (SIGSEC)
29	5.2.1.3	Develop enemy intentions
30	4.2.3	Decide on need for action or change
31	3.2.1.1	Employ air-to-air weapons
32	7.4.4.2	Evacuate casualties
33	5.1.2.1	Search for targets
.	4.4.2	Issue orders
35	7.4.4.1	Provide medical treatment
36	7.5.2.8.4 A	Issue Fuel (Class III)
37	2.1.1	Select target to attack
38	4.2.2	Project future requirements
39	6.2.2.1	Emplace mines
40	7.5.2.8.3 A	Issue Munitions (Class V)
41	7.4.2.6	Feeding
42	2.2.1.2	Adjust/illuminate Fire Support
43	7.4.3.1.4	Provide personnel management support
44	7.6.3	Provide engineer construction support
45	7.6.4	Provide engineer construction material

ORDER	TASK	
46	4.1.1.4	Receive and transmit friendly troop information
47	2.2.2.2.2 A	Counter target acquisition
48	7.5.2.4	Procure supplies
49	6.2.2.2	Prepare/emplace constructed obstacles
50	6.2.2.3	Emplace demolition obstacles
51	7.5.1.1.3	Load
52	3.3	Deny airspace
53	7.3.2.1	Perform preventive maintenance
54	4.4.1.1	Develop and complete plans oe orders
55	3.1.1	Select target to attack
56	1.1.1.1.1	Move while mounted
57	4.3.5	Select or modify course of action
58	7.5.2.2.3 A	Receive Munitions (Class V)
59	1.1.1.2	Move through air
60	7.5.2.2	Receive supplies
61	7.5.2.3 A	Produce supplies
62	7.5.2.2.4 A	Receive Fuel (Class III)
63	7.5.2.1.3 A	Request Munitions (Class V)
64	1.1.3	Navigate
65	4.1.2	Manage means of communicating information
66	6.1.2.2	Construct/repair forward airfields and landing fld
67	7.5.2.2.2 A	Receive Water
68	7.5.2.8.2 A	Issue Water
69	5.1.1.2	Collect physical environment information
70	4.1.1.3	Receive and transmit terrain and weather info
71	5.2.2.3	Develop impacts
72	7.7.2	Conduct law and order operations
73	4.1.3.4	Distribute information
74	7.5.2.2.5 A	Receive Medical (Class VIII)
75	7.5.2.1.4 A	Request Fuel (Class III)
76	6.3.4	Provide security
77	6.3.1.1.4	Use protective equipment
78	7.6.1	Rear area restoration
79	7.4.4.3	Provide preventative medicine
80	1.2.1.1.1	Select target
81	3.2.2	Conduct nonlethal attack
82	4.3.1	Issue planning guidance
83	6.3.1.2.1	Decontaminate personnel and systems
84	5.3.2	Prepare reports on enemy intentions
85	7.5.1.1.2	Unload
86	7.5.2.8.5 A	Issue Medical (Class VIII)
87	6.3.1.1.2	Prepare fighting positions
88	5.3.4	Prepare reports on enemy situation
89	7.3.2.6	Repair equipment
90	6.3.1.1.3	Prepare protective positions

ORDER	TASK	
91	7.5.1.2 A	Move/evacuate cargo, equipment, and personnel
92	7.5.2.8.1 A	Issue Classes I, II, IV, VI, VII, IX, X
93	7.5.2.1.5 A	Request Medical (Class VIII)
94	5.1.2.5	Conduct post-attack target damage assessment
95	1.1.4	Perform battlefield circulation control (BCC)
96	6.2.4	Detonate mines/explosives
97	7.3.2.7	Return repaired equipment
98	6.3.1.1.1	Employ electronic counter-countermeasures (ECCM)
99	4.4.3	Provide command presence
100	7.5.2.2.6 A	Receive Maps
101	2.2.2.2.1	Conduct jamming
102	6.3.3.2	Employ electronic deception
103	1.2.1.1.2	Select fire system
104	6.1.1.1.1	Breach minefields
105	1.1.2	Negotiate Terrain
106	7.5.2.5.2 A	Procure Water
107	1.1.1.1.2	Move while dismounted
108	7.5.2.6.3 A	Procure Munitions (Class V)
109	7.5.2.2.1 A	Receive Classes I, II, IV, VI, VII, IX, X
110	7.5.2.6.4 A	Procure Fuel (Class III)
111	4.1.3.3	Publish and reproduce information
112	7.2 A	Fuel
113	7.3.2.3	Diagnose malfunctions
114	4.1.3.2	Display information
115	7.5.2.1.1 A	Request Classes I, II, IV, VI, VII, IX, X
116	7.5.2.6.2 A	Procure Water
117	5.3.1	Prepare reports on target development
118	7.3.2.2	Recover materiel
119	7.4.3.2	Provide finance services
120	4.3.2	Develop courses of action
121	6.1.1.1.2	Breach all other obstacles
122	4.3.3	Analyze courses of action
123	7.5.2.1.2 A	Request Water
124	2.1.2.2	Determine system availability
125	6.3.2.2.1	Employ camouflage
126	6.1.1.3	Cross gaps
127	4.3.4	Compare courses of action
128	2.1.2.3	Select system
129	6.3.3.1	Employ physical deceptionEmploy physical deception
130	5.2.2.2 A	Consider status
131	5.3.3	Prepare reports on the battlefield area
132	7.5.2.8.6 A	Issue Maps
133	3.2.1.2.2	Employ other unit fires
134	6.3.1.2.2	Provide explosive ordnance disposal (EOD) support
135	6.3.2.2.2	Employ smoke/obscurants

ORDER	TASK	
136	7.5.2.6.5 A	Procure Medical (Class VIII)
137	7.5.2.1.6 A	Request Maps
138	3.1.2.3	Select system
139	3.1.2.2	Determine system availability
140	6.1.2.1	Construct/repair combat roads and trails
141	6.1.1.2	Reduce/clear obstacles
142	6.3.3.2.2 A	Employ simulative electronic deception
143	7.4.3.1.2	Conduct replacement operations
144	5.2.1.2 A	Consider enemy doctrine
145	1.3.2	Occupy terrain
146	7.5.2.6.1 A	Protect Classes I, II, IV, VI, VII, IX, X
147	6.3.3.2.1 A	Employ imitative electronic deception
148	7.4.3.6	Provide legal services support
149	5.1.1.3	Collect info on social/political/economic environ
150	4.2.1.3 A	Evaluate incoming information
151	7.4.3.4	Perform chaplaincy activities
152	6.3.3.2.3 A	Employ manipulative electronic deception
153	2.2.2.1.1	Employ incapacitating agents
154	6.3.2.1.2 A	Maintain electronic security
155	1.2.2 A	Conduct close combat
156	2.1.2.1	Determine system capability
157	7.4.3.2.3 A	Perform disbursing services
158	6.3.2.1.1.1 A	Employ physical security measures
159	6.3.2.1.1.2 A	Maintain emission security
160	7.4.3.1.1	Provide strength management
161	6.1.1.4 A	Report
162	4.2.1.1 A	Analyze mission
163	7.5.2.7.3 A	Relocate Munitions (Class V)
164	4.2.1.2 A	Fuse information
165	7.4.2.2	Graves registration
166	4.4.1.3 A	Approve orders
167	7.4.2.5 A	Bakery
168	7.4.2.3 A	Salvage
169	7.5.2.7.4 A	Relocate Fuel (Class III)
170	7.5.2.5.3 A	Procure Munitions (Class V)
171	7.4.2.1	Clothing exchange and bath
172	7.5.2.7.2 A	Relocate Water
173	7.5.2.5.4 A	Procure Fuel (Class III)
174	5.2.2.1 A	Review holdings
175	6.2.3 A	Mark obstacles
176	6.2.1 A	Secure/select location of reinforcing obstacles
177	7.4.2.4	Laundry and renovation
178	7.7.1	Perform EPW operations
179	5.2.3	Evaluate social/political/economic environment
180	3.1.2.1	Determine system capability

ORDER	TASK	
181	7.5.2.5.1 A	Procure Classes I, II, IV, VI, VII, IX, X
182	2.2.2.1.2	Conduct battlrfield psychological activities
183	7.4.3.1.3 A	Perform casualty reporting operations
184	4.1.3.1 A	Store information
185	7.5.2.5.5 A	Procure Medical (Class VIII)
186	7.5.2.7.1 A	Relocate Classes I, II, IV, VI, VII, IX, X
187	5.2.1.1 A	Review holdings
188	7.4.3.5	Provide public affairs services
189	7.3.2.4 A	Substitute parts/equipment
190	7.3.2.5 A	Exchange parts/equipment
191	7.5.2.5.6 A	Procure Maps
192	7.5.2.6.6 A	Procure Maps
193	7.5.2.7.5 A	Relocate Medical (Class VIII)
194	2.1.3 A	Develop order to fire
195	7.5.2.7.6 A	Relocate Maps
196	3.1.3 A	Develop order to fire
197	7.4.3.1.5 A	Conduct postal operations
198	7.4.3.5.1 A	Provide command information
199	7.4.3.4.1 A	Provide unit ministry
200	7.4.3.6.2 A	Administer criminal law
201	7.5.2.3.2 A	Produce Water

APPENDIX E

Acronym List

ACRONYM	EXPLANATION
	A
ADA	Air Defense
AVN	Aviation
	B
BDP	Battlefield Development Plan
BNW	Battlefield Nuclear Warfare
BOIP	Basis of Issue Plan
	C
C3I	Command, Control, Communication, and Intelligence
C3/EW	Command, Control, Communication/Electronic Warfare
CAC	Combined Arms Center
CACDA	Combined Arms Combat Developments Activity
CAMAA	Combined Arms Mission Area Analysis
CBRS	Concept Based Requirements System
CC	Command and Control
CCCA	Close Combat Capability Analysis
CCH	Close Combat Heavy
CCL	Close Combat Light
COM	Communications
CSS	Combat Service Support
	D
DCSDOC	Deputy Chief of Staff for Doctrine
	E
EMW	Engineer, Mine Warfare
EPW	Enemy Prisoner of War
EW	Electronic Warfare
	F
FC	Field Circular
FM	Field Manual
FS	Fire Support
FY	Fiscal Year
	G
GOSC	General Officer Steering Committee

I

IEW	Intelligence, Electronic Warfare

L

LOGC	Logistics Center
LOI	Letter of Instruction

M

MA	Mission Area
MAA	Mission Area Analysis
MAC	Mission Area Concept
MADP	Mission Areea Development Plan
MAT	Mission Area Threat
MOI	Memorandum of Instruction
MTP	Mission Training Plan

N

NBC	Nuclear, Biological, Chemical

P

PIP	Product Improvement Program
POI	Program of Instruction
POM	Program Objective Memorandum
PPBES	Planning, Programming, Budget, and Execution System

S

SO	Special Operations
SSC	Soldier Support Center

T

TC	Training Circular
TEC	Training Extension Course
TOE	Table of Organization and Equipment
TRAC	TRADOC Analysis Command
TRADOC	Training and Doctrine Command

APPENDIX F

Glossary of Terms

A

Air Defense (ADA). Air defense is all measures designed to nullify or reduce the effectiveness of attack by hostile aircraft or missiles after they are airborne (JCS Pub 8). Includes all weapons systems with potential to engage aerial targets. (TRADOC Pam 11-9, Blueprint of the Battlefield (Draft), 9 December 1987)

Aviation (AVN). Army aviation is an equal partner in the combined arms team, combining speed, mobility, firepower, and lift capability to rapidly move combat power to the decisive points on the battlefield. This mission area is charged with performing operations throughout the range of combat, combat support, and combat service support operations. (Army Aviation Modernization Plan, 19 May 1988)

B

Battlefield Development Plan (BDP). This document presents a perspective of the future battlefield in terms of expected environment, battle doctrine, capability assessment, and guidance to overcome problem areas. The BDP contains an integrated prioritized list of the Army's battlefield deficiencies [term replaced by capability issues after 1987] derived from 13 mission areas [thirteenth mission area changed to functional area in 1987]. This document provides a user's focus for the Army's research, development, and acquisition efforts in the areas of doctrine, training, organization, and materiel. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

Battlefield Nuclear Warfare (BNW). One of the thirteen mission areas established to conduct mission area analyses in the CBRS. It was changed to a functional area in 1987.

C

Combined Arms Center (CAC). The Combined Arms Center located at Fort Leavenworth, Kansas, is responsible for directing, coordinating, and integrating combined arms doctrinal, organizational, officer training, and training and combat developments programs for the Army. CAC is concerned with the development and dissemination of combined arms concepts, doctrine, and training management practices as they apply to functional areas of combat, combat support, command, control, and communications. (TRADOC Primer, 11 April 1984)

Combined Arms Combat Developments Activity (CACDA). The Combined Arms Combat Developments Activity at Fort Leavenworth, Kansas, is the CAC executive agent for all combat developments activities. CACDA is the "super integrator" for combined arms concepts, analyses, and requirements as they pertain to the functional areas of combat, combat support, command, control, and communications.

Combined Arms Mission Area Analysis (CAMAA). A corps perspective mission area analysis undertaken in 1985 in an attempt to bring a consistency to the Mission Area Analysis process. It was abandoned in 1987 when the Close Combat Capability Analysis was chosen as the umbrella study to provide the required corps overview for the second cycle of MAAs.

Concept Based Requirements System (CBRS). The process for determining the Army's future warfighting requirements through the development and analysis of operational concepts. These requirements, when analyzed, provide the documentation leading to the development of doctrine, training, organization, and materiel. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

Command and Control (CC or C2). Command and Control is the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. CC functions are performed through an arrangement of personnel, equipment, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission (JCS Pub 1). (TRADOC Pam 11-9, Blueprint of the Battlefield (Draft), 9 December 1987)

Close Combat Capability Analysis (CCCA). The umbrella study for the cycle of mission area analyses begun in 1987. It provided the continuity necessary by establishing the threat, force, equipment, timeframe, and scenarios to be analyzed. The CCCA provided the corps perspective needed to unify the MAA efforts.

Close Combat Heavy (CCH). The CCH mission area encompasses those combat elements of the combined arms team that are mechanized and/or armored. A team usually consists of tanks, calvary, infantry (mech), engineers (combat), and aviation assets. (FM 101-5-1, Operational Terms and Symbols, October 1985)

Close Combat Light (CCL). The CCL mission area is composed of elements of the combined arms team able to move freely. A CCL

team may consist of infantry (mech and light), engineers (combat), air defense, and aviation assets. (FM 101-5-1, Operational Terms and Symbols, October 1985)

Communications (COM). The COM mission area has the responsibility of providing reliable, responsive, and redundant communications to all units in the battlefield area of operations. (FM 101-5-1, Operational Terms and Symbols, October 1985)

Combat Service Support (CSS). The assistance provided to sustain combat forces, primarily in the fields of administration and logistics. It includes administrative services, chaplain services, civil affairs, food services, finance, legal services, maintenance, medical services, supply, transportation, and other logistical services. (FM 101-5-1, Operational Terms and Symbols, October 1985)

D

Deputy Chief of Staff for Doctrine (DCSDOC). The TRADOC Deputy Chief of Staff for Doctrine is involved primarily in the development of concepts. Among DCSDOC responsibilities are concept exploration; the concept approval process; the writing, approval, and publication of operational concepts; the Doctrinal Point of Contact Program; and the Doctrinal Literature Program. (TRADOC Primer, 11 April 1984)

E

Engineer, Mine Warfare (EMW). The EMW mission area provides the combined arms team with mobility, countermobility, survivability, general engineering, and topographic engineer services. It also provides atomic demolition munition support. (FM 101-5-1, Operational Terms and Symbols, October 1985)

F

Fire Support (FS). The FS mission area provides assistance to those elements of the ground forces which close with the enemy such as infantry and armor units, rendered by delivering artillery and mortar fire, naval gun fire, and close air support. Fire support may also be provided by tanks, air defense artillery, and Army aviation. (FM 101-5-1, Operational Terms and Symbols, October 1985)

Fiscal Year (FY). A fiscal year is the yearly accounting period for the Federal government. It covers the 12-month period starting 1 October and ending 30 September the following year. A fiscal year is designated by the calendar year in which it ends:

for example, fiscal year 1983 is the fiscal year ending 30 September 1983. (Planning, Programming, Budgeting, and Execution System [PPBES] Handbook, 3rd ed., June 1982)

G

General Officer Steering Committee (GOSC). A General Officer Steering Committee is established for major Army AR 5-5 studies to provide guidance and direction.

I

Intelligence, Electronic Warfare (IEW). The IEW mission area is responsible for providing battlefield intelligence. The product resulting from collection, evaluation, analysis, integration, and interpretation of all available information concerning an enemy force, foreign nations, or areas of operations and which is immediately or potentially significant to military planning and operations. Additionally, this mission area is responsible for taking actions to search for, intercept, locate, and identify enemy electromagnetic energy sources for the purpose of employing tactical friendly forces or exploitation for intelligence purposes. (FM 101-5-1, Operational Terms and Symbols, October 1985)

L

Logistics Center (LOGC). The Logistics Center (LOGC) located at Fort Lee, Virginia, develops and evaluates logistics concepts, doctrine, organizations, equipment, systems, and planning factors for the Army. The LOGC must ensure the integration of optimal logistical characteristics in nonlogistics combat developments, training developments, and training in schools, the other two integrating centers (CAC and SSC), and the Army. (TRADOC Primer, 11 April 1984)

M

Mission Area (MA). A mission area is a grouping of functions on the battlefield for the purposes of analysis. The proponent of a mission area is responsible for the analysis of the capability of the members of the mission area team to perform the functions and tasks required, and for proposal of solutions for deficiencies and enhancements for efficiencies identified during the analysis.

Mission Area Analysis (MAA). An assessment of programmed force capability to perform within a particular mission area. It is designed to discover deficiencies [and efficiencies] in doctrine, training, organizations, and materiel and to identify means of correcting these deficiencies [and enhancing these efficiencies]. It provides a basis for applying advanced technology to future Army operations. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

Mission Area Concept (MAC). Concepts that describe required capabilities within specific TRADOC mission areas to execute the umbrella concept. Mission area concepts contain functional appendices that describe required branch-related capabilities. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

Mission Area Development Plan (MADP). An annual plan developed by each proponent center or school which updates the MAA and outlines corrective actions for each mission area deficiency. The MADP provides a time-phased roadmap of how each proponent plans to correct each deficiency through development efforts in the areas of doctrine, training, organization, and materiel. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

Mission Area Threat (MAT). A document that outlines the ability of an enemy or potential enemy to limit, neutralize, or destroy the effectiveness of a mission area. This statement of threat is prepared in sufficient detail to support development of mission area concepts and the analysis of current mission area capabilities. A HQ TRADOC approved document prepared and maintained by a TRADOC mission area proponent threat manager. This document provides the basis to support all threat requirements for a mission area. (TRADOC Reg 11-15, Concept Based Requirements System, 4 August 1986)

N

Nuclear, Biological, Chemical (NBC). The NBC mission area has responsibility for developing and analyzing methods, plans, procedures, and training required to establish defense measures against the effects of an attack by NBC weapons. Additionally, NBC in the retaliatory defense must be considered and preparations made. (FM 101-5-1, Operational Terms and Symbols, October 1985)

P

Program Objective Memorandum (POM). The POM formally transmits to the Office of the Secretary of Defense the proposed Army program. It presents intended activities and undertakings and identifies the manpower and total obligational authority needed over the next 5-year period to build and maintain the desired force and provide and operate its sustaining base. The POM describes all aspects of Army programs to maintain and improve the capability of the total Army (Active Army, Army National Guard, Army Reserve). It highlights forces, manpower, and materiel acquisition. It also addresses the equipment distribution and logistics support required to meet the strategy and objectives specified by the Secretary of Defense. The approved POM provides the basis for budget formulation. (Planning, Programming, Budgeting, and Execution System [PPBES] Handbook, 3rd ed., June 1982)

Planning, Programming, Budget, and Execution System (PPBES). The Army PPBES renames and replaces the Army PPBS as the primary resource management system. This is the system used by the Department of Defense to establish and maintain the Five Year Defense Program (FYDP) and the defense budget. Used to administer the resource allocation process, PPBES helps assure defense capabilities needed to accomplish assigned objectives. It helps to assure effective use of available resources. (Planning, Programming, Budgeting, and Execution System [PPBES] Handbook, 3rd ed., June 1982)

S

Special Operations (SO). Military operations conducted by specially trained, equipped, and organized DOD forces against strategic or tactical targets in pursuit of national military, political, economic, or psychological objectives. They may support conventional military operations, or they may be prosecuted independently when the use of conventional forces is either inappropriate or infeasible. Special operations may include unconventional warfare, counter-terrorist operations, collective security, PSYOPS, and civil affairs measures. (FM 101-5-1, Operational Terms and Symbols, October 1985)

Soldier Support Center (SSC). The Soldier Support Center located at Fort Benjamin Harrison, Indiana, with directorates also located at Alexandria, Virginia, is the personnel and personnel systems integrator of TRADOC. SSC develops, reviews, evaluates, and conducts studies into human resource development concepts and doctrine, and integrates personnel doctrine within TRADOC schools, training activities and other integrating centers. (TRADOC Primer, 11 April 1984)

T

TRADOC Analysis Command (TRAC). The TRADOC Analysis Command is responsible for providing analytical support for all major and non-major Army studies, establishing and certifying models and scenarios for use in studies, and developing and maintaining computer wargames.

Training and Doctrine Command (TRADOC). The Commanding General, US Army Training and Doctrine Command (TRADOC) commands the principal Army school system and is responsible for combat development, training development, training, and training support activities for the Army. The purpose of TRADOC is to prepare the Army for war. (TRADOC Primer, 11 April 1984)

APPENDIX G

List of Spreadsheet Files

File Name	Bytes	Created	
RDATA.WK1	197008	7-27-88	1:03p
TET1.WK1	78926	7-05-88	8:20a
TET2.WK1	259059	6-20-88	1:05p
TET3.WK1	244684	7-05-88	1:44p
TET4.WK1	89412	7-05-88	8:31a
TET5.WK1	131122	6-21-88	2:22p
TET6.WK1	83457	6-24-88	8:07a
TET7.WK1	131570	6-22-88	9:23a
TI-1.WK1	46986	7-05-88	8:20a
TI-2.WK1	43869	7-05-88	8:23a
TI-3.WK1	38199	7-05-88	8:24a
TI-4.WK1	18108	7-05-88	8:31a
TI-5.WK1	35194	7-05-88	8:33a
TI-6.WK1	18595	7-05-88	8:34a
TI-7.WK1	35101	7-05-88	8:35a
TVK1.WK1	58497	7-05-88	11:21a
TVK2.WK1	55491	7-05-88	2:56p
TVK3.WK1	49489	7-05-88	3:42p
TVK4.WK1	30434	7-06-88	8:12a
TVK5.WK1	46691	7-06-88	9:04a
TVK6.WK1	30557	7-06-88	9:23a
TVK7.WK1	46981	7-06-88	10:29a
DET1.WK1	97865	7-06-88	1:45p
DET2.WK1	65441	7-07-88	8:46a
DET3.WK1	65358	7-07-88	9:29a
DET4.WK1	18884	7-07-88	9:43a
DET5.WK1	25914	7-07-88	10:10a
DET6.WK1	18866	7-07-88	10:14a
DET7.WK1	55410	7-07-88	10:18a
DE-1.WK1	92999	7-06-88	3:23p
DE-2.WK1	53196	7-07-88	8:44a
DE-3.WK1	50793	7-07-88	9:28a
DE-4.WK1	12980	7-07-88	9:42a
DE-5.WK1	19339	7-07-88	10:09a
DE-6.WK1	12980	7-07-88	10:13a
DE-7.WK1	43711	7-07-88	10:16a
DEK1.WK1	109199	7-06-88	3:00p
DEK2.WK1	80058	7-07-88	11:51a
DEK3.WK1	76912	7-07-88	1:19p

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DEK5.WK1	40180	7-07-88	1:55p
DEK6.WK1	32802	7-15-88	9:45a
DEK7.WK1	68350	7-07-88	2:51p
CVK1.WK1	246280	7-14-88	1:38p
CVK1-A.WK1	202723	7-13-88	4:53p
CVK1-B.WK1	137579	7-12-88	12:04p
CVK1-37.WK1	88466	7-18-88	8:19a
CVK1-46.WK1	88466	7-18-88	8:17a
CVK1-55.WK1	88466	7-18-88	8:13a
CVK1-64.WK1	88466	7-18-88	8:21a
CVK1-SA.WK1	320484	7-28-88	10:02a
CVK2.WK1	161414	7-14-88	2:23p
CVK2-A.WK1	104529	7-12-88	4:55p
CVK2-B.WK1	100836	7-12-88	4:45p
CVK2-37.WK1	60309	7-18-88	9:04a
CVK2-46.WK1	60309	7-18-88	9:03a
CVK2-55.WK1	60309	7-18-88	9:01a
CVK2-64.WK1	60309	7-18-88	9:06a
CVK2-SA.WK1	189625	7-20-88	5:01p
CVK3.WK1	110880	7-21-88	1:43p
CVK3-A.WK1	97257	7-13-88	9:50a
CVK3-B.WK1	81879	7-13-88	10:26a
CVK3-37.WK1	54480	7-22-88	8:08a
CVK3-46.WK1	126239	7-21-88	2:54p
CVK3-55.WK1	115104	7-22-88	10:46a
CVK3-64.WK1	126239	7-22-88	10:55a
CVK3-SA.WK1	227254	7-21-88	2:09p
CVK4.WK1	41890	7-15-88	12:33p
CVK4-A.WK1	59911	7-15-88	12:12p
CVK4-37.WK1	15989	7-18-88	9:46a
CVK4-46.WK1	15989	7-18-88	9:45a
CVK4-55.WK1	15989	7-18-88	9:44a
CVK4-64.WK1	15989	7-18-88	9:43a
CVK4-SA.WK1	47716	7-27-88	8:48a
CVK5.WK1	59760	7-14-88	3:20p
CVK5-A.WK1	94891	7-13-88	1:09p
CVK5-37.WK1	22325	7-18-88	10:08a
CVK5-46.WK1	22325	7-18-88	10:07a
CVK5-55.WK1	22325	7-18-88	10:07a

File Name	Bytes	Created	
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CVK6.WK1	42053	7-15-88	2:37p
CVK6-A.WK1	60088	7-15-88	1:54p
CVK6-37.WK1	15998	7-18-88	10:20a
CVK6-46.WK1	15998	7-18-88	10:19a
CVK6-55.WK1	15998	7-18-88	10:18a
CVK6-64.WK1	15998	7-18-88	10:23a
CVK6-SA.WK1	47480	7-27-88	8:46a
CVK7.WK1	130444	7-14-88	4:19p
CVK7-A.WK1	154592	7-14-88	8:11a
CVK7-37.WK1	49275	7-18-88	10:36a
CVK7-46.WK1	49275	7-18-88	10:34a
CVK7-55.WK1	49275	7-18-88	10:33a
CVK7-64.WK1	49275	7-18-88	10:38a
CVK7-SA.WK1	162139	7-27-88	11:29a
CVK-37.WK1	347398	7-22-88	8:55a
CVK-37A.WK1	353478	7-18-88	2:18p
CVK-37B.WK1	320425	7-22-88	8:41a
CVK-46.WK1	320419	7-21-88	3:15p
CVK-46A.WK1	283611	7-19-88	10:33a
CVK-46B.WK1	282103	7-19-88	11:08a
CVK-55.WK1	320102	7-22-88	3:35p
CVK-55A.WK1	287028	7-19-88	8:22a
CVK-55B.WK1	271393	7-19-88	8:57a
CVK-64.WK1	340321	7-22-88	11:58a
CVK-64A.WK1	294788	7-20-88	11:22a
CVK-64B.WK1	321393	7-20-88	11:35a
ORDER-37.WK1	58148	7-19-88	7:36a
ORDER-46.WK1	83980	7-19-88	8:30a
ORDER-55.WK1	58080	7-19-88	9:22a
ORDER-64.WK1	57802	7-19-88	12:25p
ORDER-SA.WK1	68302	7-19-88	1:46p
MERGE.WK1	97538	7-29-88	10:45a
MACROS.WK1	3841	6-21-88	11:00a
MAC-1.WK1	18189	7-06-88	9:06a

File Name	Bytes	Created	
MAC-2.WK1	3923	7-08-88	9:37a
MAC-3.WK1	3878	7-07-88	9:39a
MAC-4.WK1	3486	7-07-88	2:06p
MAC-5.WK1	3142	7-08-88	11:14a
MAC-7.WK1	3851	7-11-88	3:10p
MAC-8.WK1	5825	7-13-88	7:33a
MAC-10.WK1	5095	7-13-88	1:15p
MAC-12.WK1	3534	7-14-88	3:22p
MAC-13.WK1	1940	7-14-88	12:14p
MAC-14.WK1	1720	7-14-88	9:30a
MAC-15.WK1	1911	7-14-88	11:35a
MAC-16.WK1	1698	7-18-88	8:58a
MAC-17.WK1	1912	7-18-88	11:12a
MAC-18.WK1	1770	7-18-88	11:31a
MAC-20.WK1	2064	7-19-88	8:15a